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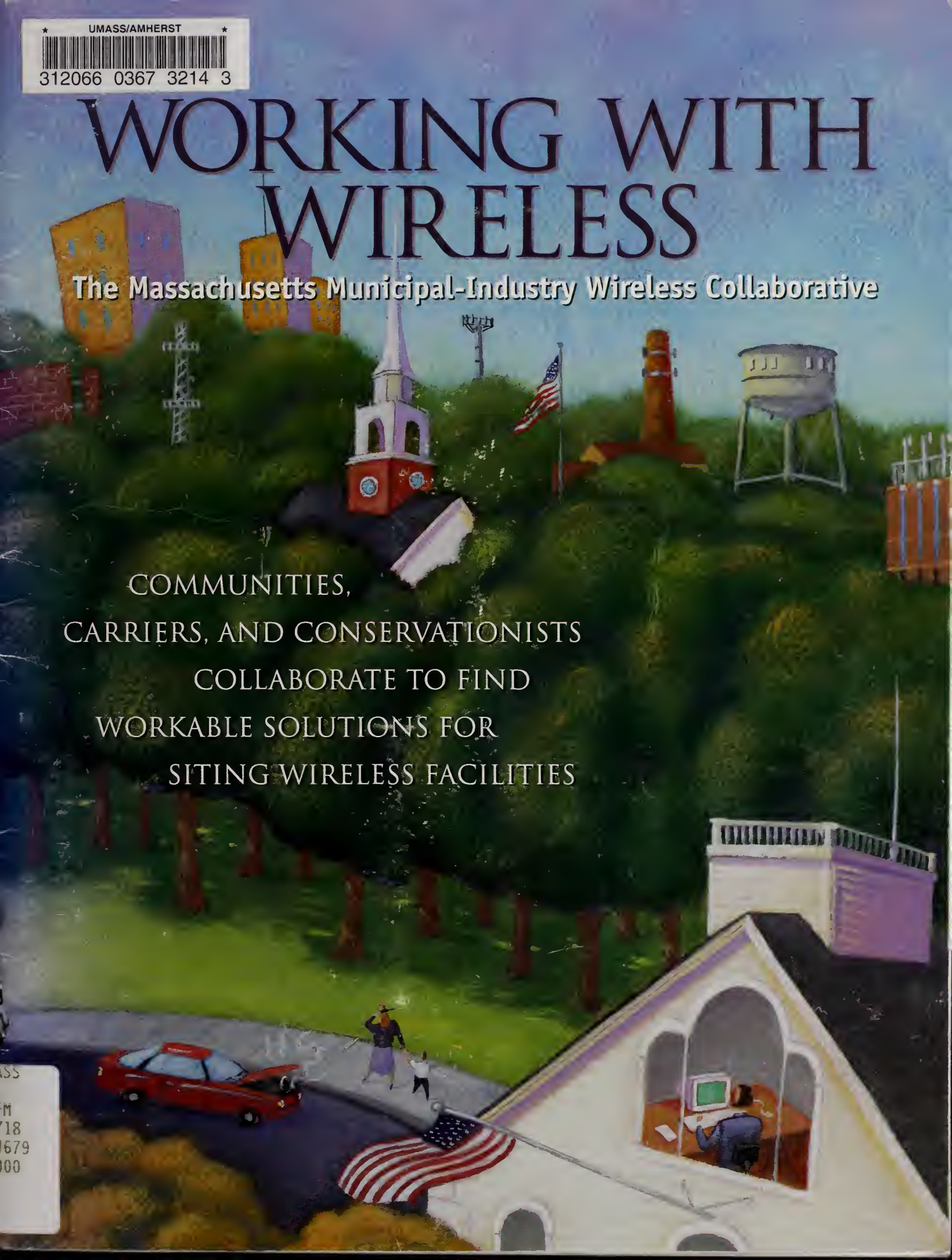
WORKING WITH WIRELESS

The Massachusetts Municipal-Industry Wireless Collaborative



COMMUNITIES, CARRIERS, AND CONSERVATIONISTS COLLABORATE TO FIND WORKABLE SOLUTIONS FOR SITING WIRELESS FACILITIES

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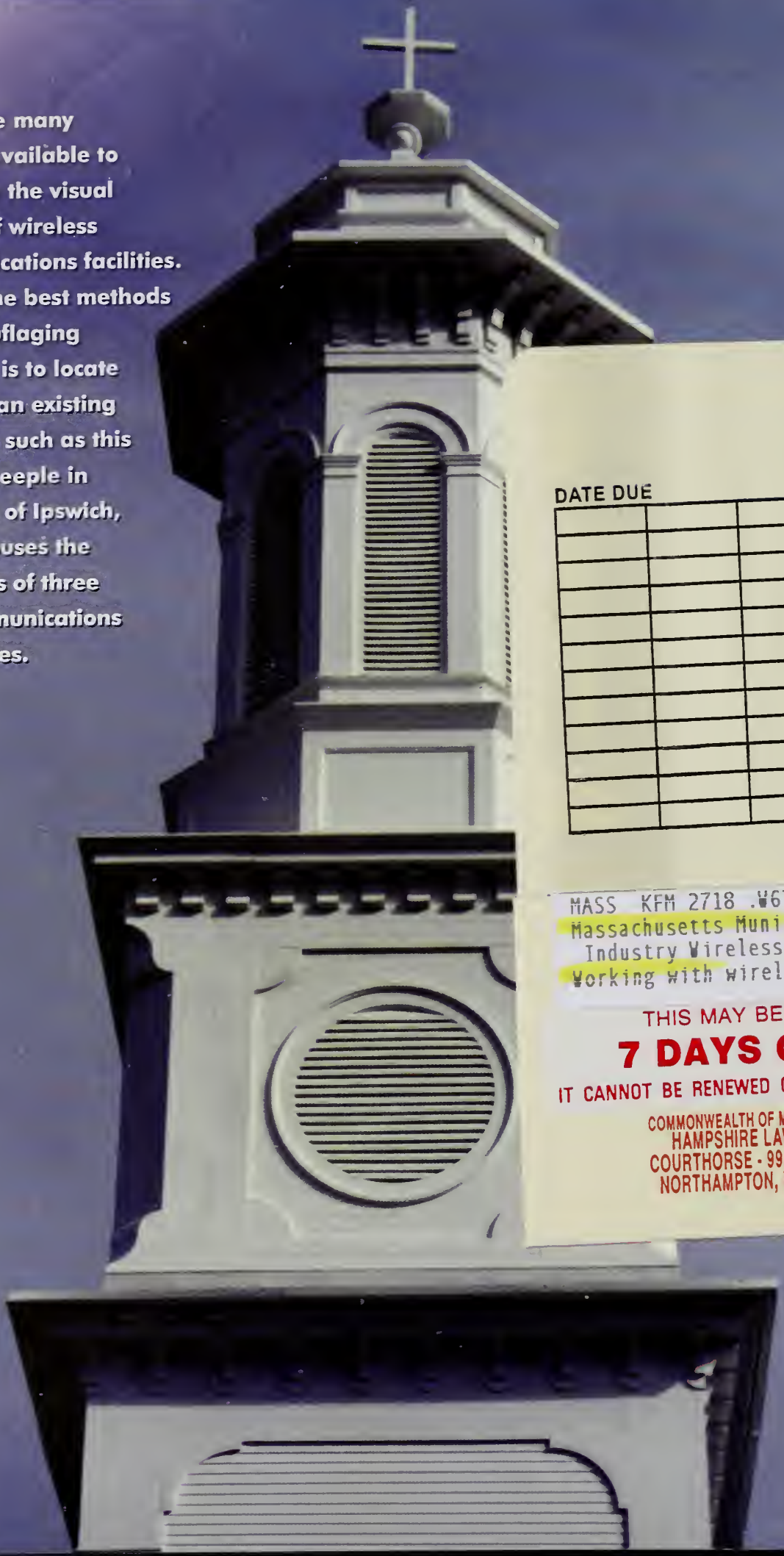
There are many options available to minimize the visual impact of wireless communications facilities. One of the best methods of camouflaging a facility is to locate it inside an existing structure such as this church steeple in the town of Ipswich, which houses the antennas of three telecommunications companies.



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WORKING WITH WIRELESS

The Massachusetts Municipal-Industry Wireless Collaborative

Communities, Carriers, and Conservationists
Collaborate to Find Workable Solutions for Siting Wireless Facilities

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Massachusetts Municipal Association
60 Temple Place, Boston, Massachusetts 02111

LETTER FROM THE EXECUTIVE DIRECTOR

Dear Local Official,

The Massachusetts Municipal Association (MMA) is pleased to present you with *Working With Wireless: Communities, Carriers, and Conservationists Collaborate to Find Workable Solutions for Siting Wireless Facilities.*

This comprehensive reference guide provides you with invaluable information on the highly complex issue of the siting of wireless telecommunications facilities. It is our hope that this publication will be read and used by every local official who is involved in making decisions concerning the zoning, planning, and siting process for wireless facilities.

This reference and education guide has been written to meet the needs of community leaders, who are seeking accurate and credible information to address the growth of this new technology. The authors and contributors include independent experts, municipal advocates, and industry officials. *Working With Wireless* is the only publication of its type that has been written exclusively for the benefit of Massachusetts local officials.

This education guide is just part of the MMA's ongoing commitment to providing its member communities with useful and important information concerning vital issues affecting the state's cities and towns. We will continue to offer new, expanded services and publications designed to build a strong future for local government.

Sincerely,

Geoffrey C. Beckwith
Executive Director

The Massachusetts Municipal-Industry Wireless Collaborative

LETTER FROM THE PARTICIPANTS

Dear Reader,

Cities and towns across Massachusetts are facing more complex policy challenges than ever before. Information technology has emerged as a driving force that is revolutionizing our economy and changing our society. Local officials are striving to protect the public interest in the face of these changes. Telecommunications companies, meanwhile, are striving to provide the public with quality services in an increasingly competitive environment.

In a time of great change, the only way to survive and flourish is to do what citizens in this country have done so well for so long—work together for innovative solutions. This is what the Massachusetts Municipal-Industry Wireless Collaborative is all about.

In the spring of 1998, leaders of the Massachusetts Municipal Association, the Conservation Law Foundation, and the Massachusetts Wireless Industry Coalition sat down to discuss the possibility of working together to develop recommendations to resolve the disputes regarding the build-out of the wireless telecommunications network. Instead of simply squaring off to do battle before the Legislature and the courts, the leaders of these organizations thought it would be more productive to explore an innovative collaboration focused on developing policy suggestions for local officials and the industry.

The result was the formation of the Massachusetts Municipal-Industry Wireless Collaborative. The MMA, CLF, and four wireless telecommunications companies—AT&T Wireless Services, Bell Atlantic Mobile, Cellular One, and Nextel Communications—were the founding members. Omnipoint Communications and Sprint PCS joined the Collaborative a year later.

The publication of this education guide for local officials demonstrates that this joint effort can benefit everyone. Local officials now have direct access to the latest information and ideas concerning every facet of the build-out of the wireless telecommunications network. The Collaborative will be following up this success by presenting educational workshops for local officials and developing model legislation that offers a common-ground approach to the siting of wireless facilities.

Governing in today's world is more difficult than ever. Issues have never been as complicated. Change is coming faster and faster. Those of us in the Massachusetts Municipal-Industry Wireless Collaborative appreciate the opportunity to be part of an effort to assist the leaders of local government in meeting the challenges ahead.

For the Municipal Participants,

Geoffrey C. Beckwith
Executive Director, MMA

For the Conservation Law Foundation,

John A. Pike, Esq.
Attorney

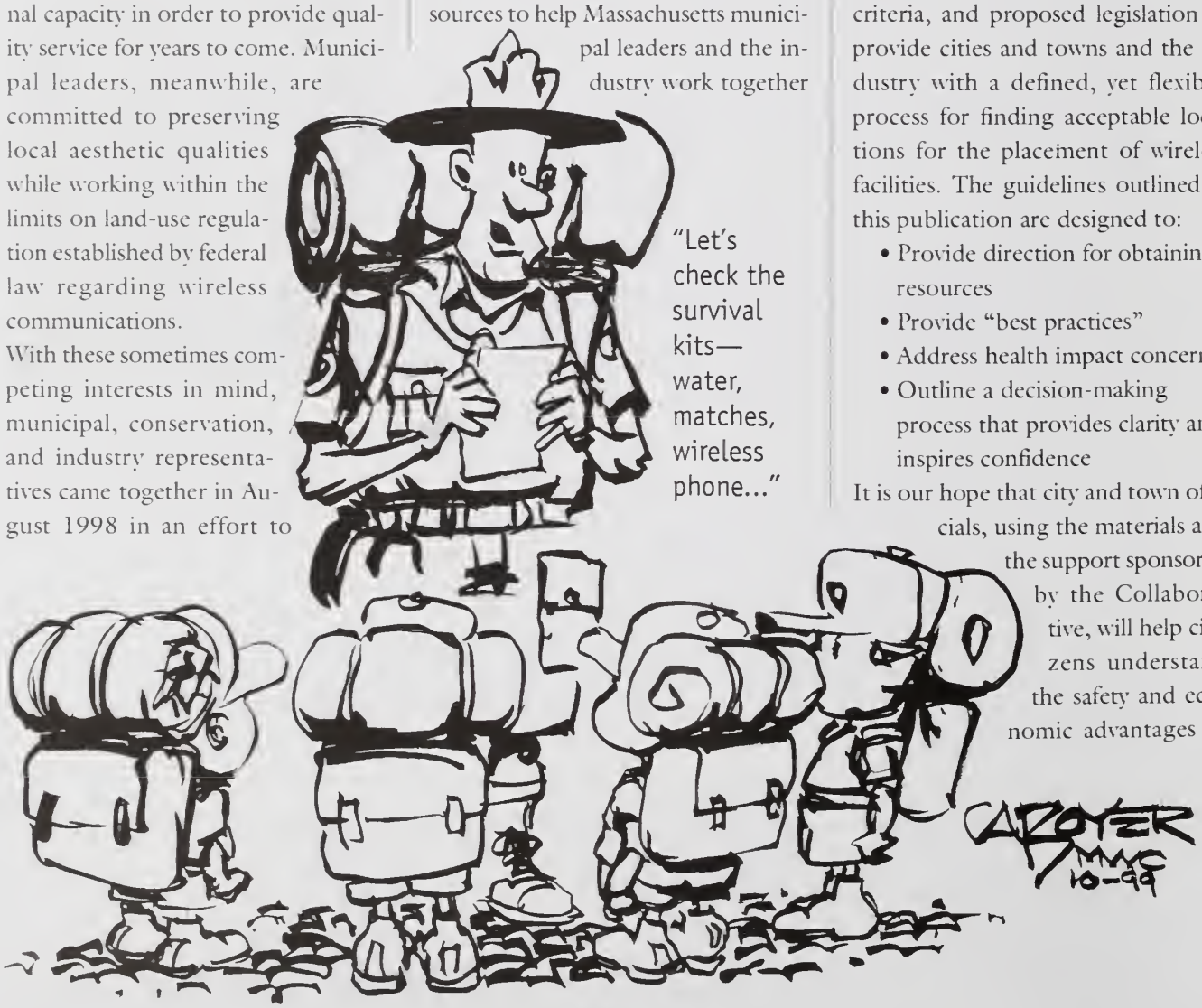
For the Industry Participants,

Neil L. Chayet, Esq.
Attorney for AT&T Wireless Services,
Rep. of the Industry Coalition

Introduction to the Massachusetts Municipal-Industry Wireless Collaborative

The spiraling demand for state-of-the-art wireless communication services and the requirement that licensed carriers provide "reliable service coverage" are fueling vigorous development of the wireless infrastructure. The industry is striving to close coverage gaps and increase signal capacity in order to provide quality service for years to come. Municipal leaders, meanwhile, are committed to preserving local aesthetic qualities while working within the limits on land-use regulation established by federal law regarding wireless communications.

With these sometimes competing interests in mind, municipal, conservation, and industry representatives came together in August 1998 in an effort to bridge the gap of understanding and promote better working relationships. All members of the Massachusetts Municipal-Industry Wireless Collaborative recognize that cities and towns must retain the authority to reasonably regulate the placement, construction, and modification of wireless facilities. A key purpose of the Collaborative is to provide education and resources to help Massachusetts municipal leaders and the industry work together to better manage wireless carrier installation requests.



"Let's check the survival kits—water, matches, wireless phone..."

EDUCATION INITIATIVE

Over the past year, the Collaborative met for countless hours, hired a project manager, retained several technical consultants, and engaged independent legal experts. The Collaborative developed guidelines and criteria, and proposed legislation to provide cities and towns and the industry with a defined, yet flexible, process for finding acceptable locations for the placement of wireless facilities. The guidelines outlined in this publication are designed to:

- Provide direction for obtaining resources
- Provide "best practices"
- Address health impact concerns
- Outline a decision-making process that provides clarity and inspires confidence

It is our hope that city and town officials, using the materials and the support sponsored by the Collaborative, will help citizens understand the safety and economic advantages of

an improved wireless network as well as the opportunity to minimize its environmental impact. Information offered in these pages could become the basis for new or revised bylaws and serve as a resource for municipal officials who are formulating policy relating to a proposed wireless facility.

> "THE COLLABORATIVE DEVELOPED GUIDELINES AND CRITERIA, AND PROPOSED LEGISLATION TO PROVIDE CITIES AND TOWNS AND THE INDUSTRY WITH A DEFINED, YET FLEXIBLE, PROCESS FOR FINDING ACCEPTABLE LOCATIONS FOR THE PLACEMENT OF WIRELESS FACILITIES."

FINDING COMMON GROUND

The Federal Communications Commission requires licensed wireless service carriers to provide "reliable service coverage." Failure to achieve this could result in loss of a license. The objective of wireless carriers, then, is to meet the FCC requirements as well as to improve service by implementing state-of-the-art technology through a timely and predictable "build-out" process. The controversy ensues, however, when cities and towns exercise their permit-granting authority and their obligation to protect local aesthetics and protect their citizens by controlling growth.

A successful wireless build-out process will help to achieve a high level of customer satisfaction by providing Massachusetts with an advanced and competitive telecommunications system while minimizing community impact. The expected result of this publication and other Collaborative resources is an open, knowledge-based local permitting process that serves both municipalities and the industry.

Cities and towns will benefit through the cooperation of community and industry resources and, thus, avoid the cost of lengthy and expensive litigation. Carriers will benefit by avoiding costly permitting delays and litigation, thereby freeing these resources for investments in new technology, better service, and mitigation. Key byproducts of this effort are expected to be learning and compromise by all parties that will lead to a consensus for action. ■

"Stealth" technology utilizes special materials and designs to make this wireless facility look like a flagpole. © OMNIPOINT COMMUNICATIONS

The Growth of the Wireless Industry

Digital, *spectrum*, *networks*, and *wireless* are just a few of the words that now define an entire industry of communications and are part of the everyday jargon of wireless phone users. Remember the days when having push-buttons on a traditional wireline telephone was considered advanced technology? The wireless communications industry catapulted into the 1990s with advancements in technology, the emergence of competition, and a scramble to fulfill the public's insatiable demand for more advanced, faster, clearer, and less expensive wireless communications. A far cry from the original $3,000 price tag for the first clunky cell phones installed in cars.

AT&T's Bell Laboratories developed the cellular concept in 1947 and the possibilities of commercial applications were tested twenty years later. In the late 1960s to early 1970s, work began on the first cellular telephone system, AMPS (Advanced Mobile Phone Service). Throughout the 1970s, the Federal Communication Commission (FCC) started proceedings and rule-makings to allocate spectrum for cellular systems, and by the late 1980s, the FCC had granted each of the two cellular licenses in most areas of the country.

In the late 1980s, interest emerged in a digital cellular system, allowing greater system capacity and enhanced features. During the 1990s, as the two traditional cellular com-

Table 1. CTIA's Annualized U.S. Wireless Industry Survey Results, June 1985 to June 1999.

Year	Estimated Total Subscribers	Annual Total Service Revenues (000s)	Annualized Roamer Revenues (000s)	Cell Sites	Direct Service Provider Employees	Cumulative Capital Investment (000s)	Average Local Monthly Bill	Average Local Call Length
1985	203,600	354,316	N/A	599	1,697	588,751	N/A	N/A
1986	500,000	666,782	N/A	1,194	3,556	1,140,163	N/A	N/A
1987	883,778	941,981	N/A	1,732	5,656	1,724,348	N/A	N/A
1988	1,608,697	1,558,080	N/A	2,789	9,154	2,589,589	$95.00	2.25
1989	2,691,793	2,479,936	210,699	3,577	13,719	3,675,473	$85.52	2.35
1990	4,368,686	4,060,494	365,549	4,768	18,973	5,211,765	$83.94	2.32
1991	6,380,053	5,075,963	565,989	6,685	25,545	7,429,739	$74.56	2.20
1992	8,892,535	6,688,302	838,077	8,901	30,595	9,276,139	$68.51	2.38
1993	13,067,318	9,008,700	1,124,493	11,551	36,501	12,775,967	$67.31	2.38
1994	19,283,306	12,591,947	1,552,382	14,740	45,606	16,107,921	$58.65	2.36
1995	28,154,415	16,460,516	2,173,003	19,844	60,624	21,721,711	$52.45	2.27
1996	38,195,466	21,525,861	2,737,177	24,802	73,365	26,707,046	$48.84	2.24
1997	48,705,553	25,575,275	2,858,432	38,650	97,039	37,454,294	$43.86	2.25
1998	60,831,431	29,637,742	3,166,656	57,674	113,111	50,178,812	$39.88	2.34
1999	76,284,735	37,214,819	3,837,994	74,157	141,929	66,782,827	$40.24	2.40

Source CTIA

panies in each market migrated from analog to digital networks, the newly licensed personal communications systems (PCS) hit the market, building out their respective digital networks on the heels of the Enhanced Specialized Mobile Radio (ESMR) providers entering the digital-cellular mix with their new networks. This fury of activity resulted in cheaper, better wireless services. These systems

> "EXPERTS ESTIMATE THAT BY THE END OF THE YEAR 2000, THERE WILL BE 200 MILLION WIRELESS PHONE USERS AROUND THE WORLD."

are capable of supporting voice, text, fax, graphics, and data. They are the essence of personalized communications.

Each day, more than 3,000 new customers sign up for wireless phone service. The Cellular Telecommunications Industry Association (CTIA) estimates that two-thirds of new subscribers buy service for safety, security, and personal convenience, rather than business reasons. The increase in wireless emergency 911 calls over the last ten years speaks volumes. Nearly 36 million wireless 911 distress calls were received in 1998, compared to just 193,000 in 1985. Experts estimate that by the end of the year 2000, there will be 200 million wireless phone users around the world. The direct employment by wireless service providers grew from 3,556 as of June 1986 to 141,929 as of June 1999, with an estimated 1.3 million jobs in the U.S. economy arising out of the industry in general.

The new demand for additional wireless services requires physical infrastructure in order to build the networks. Some would argue that this requirement is a high price to pay, while others point to the history and development of industries such as railroads and utilities, which required a nationwide infrastructure in order to advance both technological and economic growth. What is clear is that the information revolution has arrived, and advanced wireless technology is rapidly forging ahead. ■

Figure 1. U.S. Wireless Subscribership: June 1985 to June 1999

Source CTIA

This is an example of a monopole, a slender self-supporting tower on which the panel antennas of one carrier have been mounted at the top. © COMP COMM INC.

Projected Service Needs

The future of all communication is increased accessibility, connectivity, and ease of use. Though it may be difficult to make actual projections of the wireless communications market in figures, one only has to look at the rapid growth of the market's recent past to imagine what its future might be. The convergence of communications media—voice, data, video, Internet, print, cable—is producing significant changes that are just starting to materialize. Technological advances occur by the day and are rapidly handed down to the consumer.

Five years ago, how many people did you know who carried a wireless phone? Whose child carried a wireless phone? How many people owned a personal computer? Or had access to the Internet? What about today? More than 100 million U.S. wireless users are predicted by the end of the year 2000. How will the answers change five years from now?

In a society that is increasingly mobile and hungry for instant access to communications and information, technological innovations are moving from the realms of novelty or luxury to necessity.

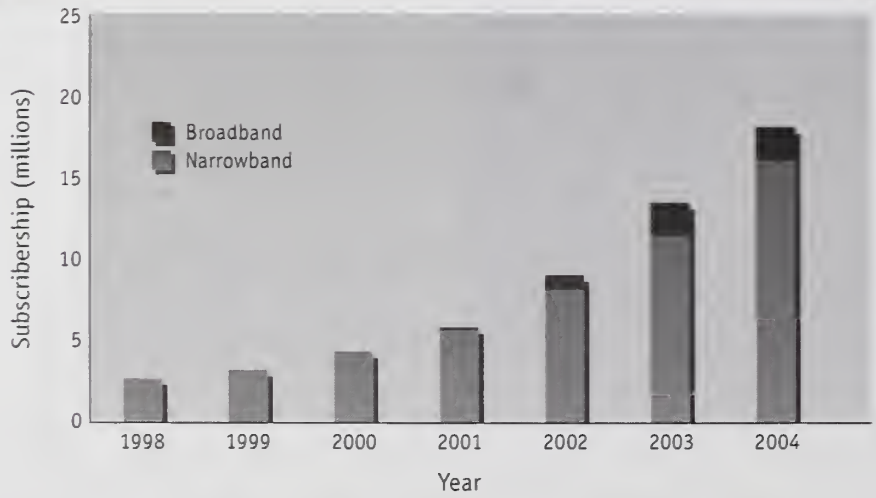
Based on current research, here are some predictions of trends in the wireless arena and how they might impact you and your community:

CUTTING THE CORD?

The top five wireless communications carriers controlled forty-eight percent of the U.S. wireless market in 1998, according to research conducted by RCR, a weekly wireless communications publication. After all of the pending telecommunications mergers are completed, these five carriers will control seventy percent of the U.S. market. These big carriers, with big coverage footprints, are able to offer big buckets of flat-rate minutes with no roaming and no long distance charges.

The race is on for companies to attract as many new subscribers as possible in an effort to stake a claim to the largest market share. Some big carriers even hope consumers might give up their landline phone for wireless flat-rate plans. (This "cutting the cord" is not really occurring, according to Allied Business Intelligence; rather, leftover wireless bucket minutes are being used to supplement home landline use.) On average, U.S. wireless users are replacing twelve percent of their wireline traffic with wireless phone use, according to the 1999 Yankee Group Mobile User Survey. Yankee predicts that this number will rise to seventeen percent in 2001, an unexpected and significant area for wireless user growth.

Figure 1. Narrowband and Wireless Broadband Data Subscribers, 1998–2004



Source: The Strategis Group

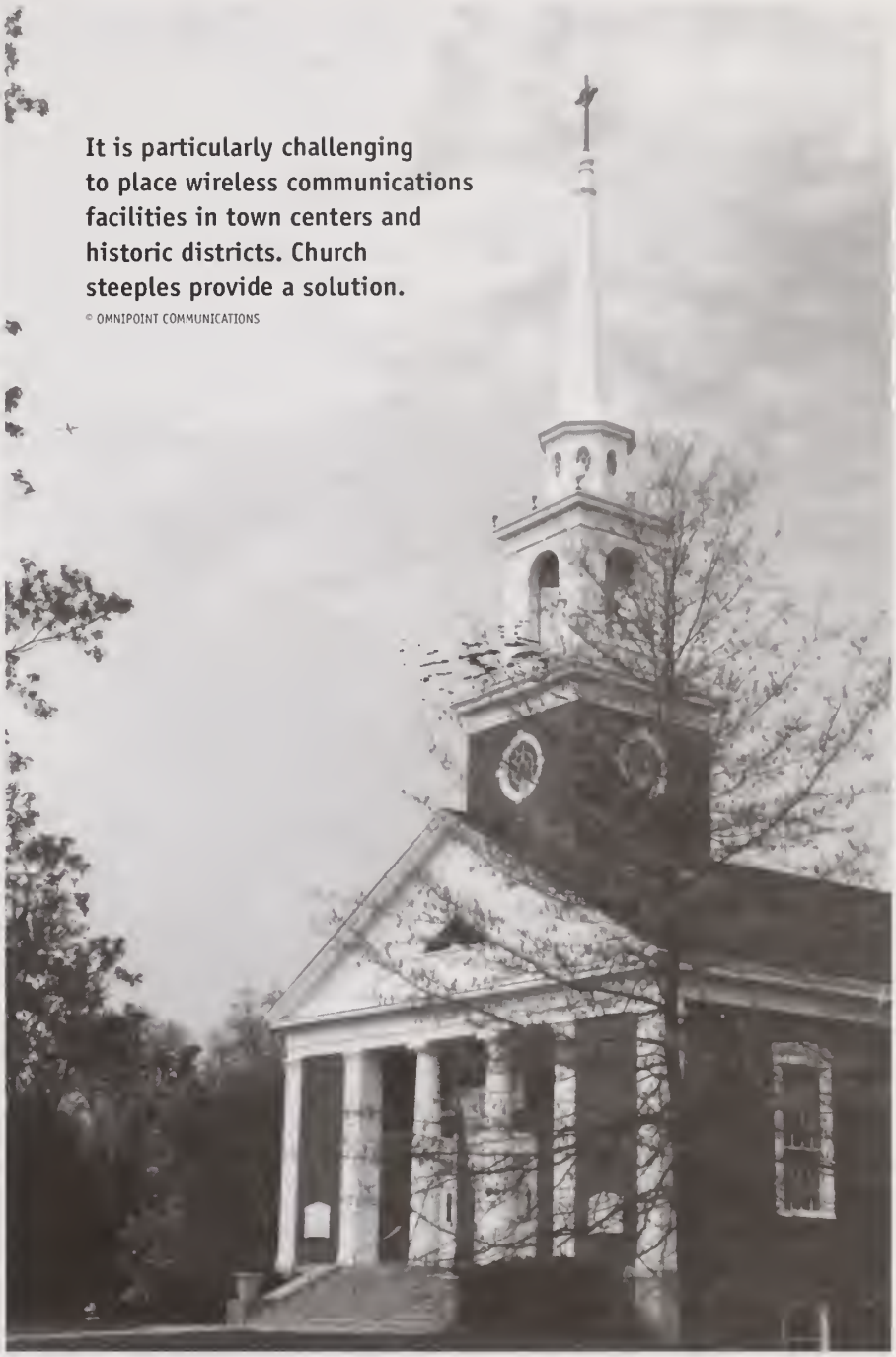
MOBILE DATA

The increasing popularity of the Internet also will fuel demand for wireless data services. The Strategis Group reports that Internet connectivity is a main driver for mobile data solutions. A recent Strategis study showed that 32 million workers are candidates for this type of service, although the market is relatively untapped, with only 2.8 million mobile

users today. The Strategis Group predicts that recent advancements in smart phone, two-way pager and personal digital assistant technology will make wireless data applications more and more feasible; Strategis forecasts 21.5 million mobile data users by 2004.

Although there are dozens of applications being tried and tested for mobile data, it is access to the Internet, e-mail messaging, and mobile access to banking and investments that are likely to be major uses. The lack of a uniform industry technology standard for mobile data is what has slowed, and may continue to hinder, this segment of the market. Several standards are in use and being considered by various industry groups, but a clear winner has yet to emerge. When a standard is chosen, mobile data applications and users are likely to grow in line with the figures previously discussed.

> "WHILE MOST WIRELESS CARRIERS HAVE BUILT OUT THEIR MAJOR MARKET NETWORKS, MUCH WORK REMAINS TO COMPLETE SECONDARY MARKETS AND TO FILL COVERAGE GAPS."



It is particularly challenging to place wireless communications facilities in town centers and historic districts. Church steeples provide a solution.

© OMNIPOINT COMMUNICATIONS

COVERAGE AND CAPACITY

Those carriers who have not jumped into the merger and acquisition fray in order to gain national coverage must differentiate themselves by providing superior quality, coverage, and capacity to their local markets. This requires growing the network with the subscriber base. While most wireless carriers have built out their major market networks, much work remains to complete secondary markets and to fill coverage gaps.

Growing subscriber numbers also raise capacity issues. With more and more users on the network, the network becomes taxed and additional infrastructure is needed to expand capacity or service quality will

suffer. Without added capacity, users will experience service problems and interruptions.

In short, carriers will need to continue building their networks to meet both coverage and capacity needs. And an expanded network—whether for coverage or capacity reasons—means more antennas and more sites.

EMERGING TECHNOLOGY

Now and in the future, wireless technology usage is expanding well beyond the traditional person-to-person voice communication on a handset. For example, the use of satellite communication, mobile computing, and personal digital assistant technology is increasingly popular among technology-savvy professionals and mainstream consumers alike. People want to stay connected to their office, their home, and their family while traveling internationally or just around the neighborhood.

> "WHAT CAN BE SAID WITH REASONABLE CERTAINTY IS THAT MOBILE COMMUNICATIONS ARE HERE TO STAY. THAT DEMAND FOR THESE SERVICES WILL CONTINUE TO GROW. AND THAT THIS GROWTH WILL REQUIRE A CORRESPONDING GROWTH IN THE WIRELESS INFRASTRUCTURE."

Mobile computing aids service people in hundreds of fields by providing instant remote access to data and allowing the user to update such information remotely. In remote or hard-to-reach areas, especially internationally, where the use of traditional copper telecommunications is too difficult or expensive, the wireless industry provides solutions including personal communications service (PCS) over cable, wireless local loop, and in-building wireless systems.

While no one knows exactly which technologies and which services will be the market leaders of the future, the answer is likely to be "many of the above," plus a few more that haven't even been thought of yet. For example, satellite-based services will likely come down in price and increase in availability, but they are unlikely to replace terrestrial wireless facilities. It is more probable that they will coexist, with each company offering services that appeal to different segments of the consumer population.

What can be said with reasonable certainty is that mobile communications are here to stay, that demand for these services, in whatever form, will continue to grow, and that this growth will require a corresponding growth in the wireless infrastructure.

So what does this mean for the future of your neighborhood? In the relatively near future (two to four years), we can expect the need for more antennas and, with the exception of areas with lots of existing tall structures, a corresponding need for more towers.

> "SATELLITE-BASED SERVICES WILL LIKELY COME DOWN IN PRICE AND INCREASE IN AVAILABILITY. BUT THEY ARE UNLIKELY TO REPLACE TERRESTRIAL WIRELESS FACILITIES."

As we move further into the future, where sites are serving more densely populated subscriber zones (more mobile users per square mile), the location of new sites will be driven more by capacity than by coverage, and sites will be located closer and closer together. Thus, each site will be required to cover a smaller geographic area, so many new facilities might then be located on lower structures.

So we may eventually see the emergence of antennas on streetlights on every block instead of new super-tall towers every mile. But this is still some time away.

The investment has already been made in the existing infrastructure, so the towers we have today aren't going anywhere anytime soon, and more infrastructure is needed now, using today's technology. ■

From the Municipal Perspective

The two principal participants in the siting of wireless telecommunications facilities, local governments and wireless service providers, are frequently at odds. One reason is that they each believe that their own roles serve the greater public good and that the other party threatens to undermine their important work. In short, each side questions the other's values and motives.

For local governments, the siting process seems to be part of a continuous struggle to protect their authority to make zoning and siting decisions. Communities see this threat coming directly from federal and state decision makers, as well as from industries armed with special powers granted by those federal and state authorities. Though most of those who work at the local level would prefer unabridged decision-making authority, they recognize the occasional practice of state or federal action when it is demonstrated to be necessary for the good of the larger population.

The difficulty for local officials, especially in the siting of wireless communication facilities, is separating the federal public policy goal—ensuring the development of viable and competitive wireless communications networks—from the commercial interests of this highly competitive industry, and making sure that these commercial interests do not have a negative impact on their community.

Local governments have the constitutional authority to control the use of their land and the responsibility to make decisions that protect the visual and aesthetic character of their communities. However, municipalities often face challenges in fulfilling those roles. Many local governments rely on part-time volunteer boards and limited resources when dealing with these complex and important quality-of-life questions. Further, local officials find themselves between a rock and a hard place when their citizens are split on what the best decision may be for their community or neighborhood.

Antennas can be mounted on existing structures such as this water storage tank with little or no additional visual impact.

© NEXTEL COMMUNICATIONS

On the other side is an industry that is driven by federal regulation and the marketplace to build out a network that requires an extensive infrastructure. The wireless service providers have been aided by federal and state regulatory agencies that are determined to ensure the existence of a competitive marketplace. The wireless carriers have the ability to appeal to the courts to overturn unfavorable local decisions. In Massachusetts, the carriers can use and benefit from the state regulatory powers of the Department of Telecommunications and Energy. A denial from a community is not necessarily a final decision that binds the industry.

The relationship between municipalities, federal and state governments, and the wireless communications industry is enormously complex. Striking and maintaining a balance between all of these players and interests is the most difficult aspect of developing appropriate public policy on this issue. ■

The Federal Framework for Regulation of Wireless Communications

The federal government has played a prominent role in wireless communications since the technology's inception. Licenses to use the radio spectrum—be it for television broadcasting or wireless communications—are granted by the Federal Communications Commission, which also creates the rules and regulations that govern the use of the spectrum. In the past, states had certain rights to regulate wireless communications, usually through the state public utility commission, but a provision in the 1993 federal budget act took the right to regulate market entry and fees away from the states. The states kept their ability to regulate the terms and conditions of service and other consumer issues.

By the mid 1980s, the FCC had granted two licenses for 800 MHz cellular wireless communications in each of the 360 largest metropolitan areas in the United States. In most cases, one license went to the existing (or "incumbent") local telephone company (e.g., NYNEX here in Massachusetts) and the other was granted to a competitive wireless provider (e.g., Cellular One in Massachusetts).

The FCC also licensed one or two companies to provide Enhanced Specialized Mobile Radio (ESMR) service, which has traditionally been used for fleet two-way communications but is now also being used for digital wireless phone service with the added dispatch feature (e.g., Nextel in Massachusetts).

In 1995, the FCC began auctioning large blocks of spectrum in the 1900 MHz frequency range to be used for commercial wireless services. These services were labeled PCS, for personal communications services. In each geographic area, up to six licenses were auctioned. One of the purposes of the auction was to increase competition in wireless communications. New licensees joined existing carriers in providing service, increasing the number of carriers in any given market from the two existing cellular carriers to as many as six or eight. The federal government hoped that the increased availability of spectrum would make wireless communications more available and, through the competitive process, more affordable for consumers.

As the carriers began to use their newly licensed spectrum and to build out their networks, it became clear that many issues dealing with a competitive telecommunications marketplace had to be regulated by law. In order to address these issues, Congress enacted the Telecommunications Act of 1996.

WHAT IS THE TELECOMMUNICATIONS ACT?

The Telecommunications Act of 1996 is an amendment to the Telecommunications Act of 1934 (known legally as 47 U.S.C. 151, et seq.). While the Telecommunications Act of 1996 (the "Act") deals with many telecommunications issues, such as competition among providers of local phone service and access to rights of way, Section 332 (c) (8) deals with the siting of wireless communications facilities. The Act affects how municipal and state governments may make decisions about the placement, construction, and modification of wireless communications facilities. The Act does not change the FCC's exclusive jurisdiction and control over technical standards and its right to license spectrum. It also makes clear that local or state regulation may not act as a barrier for wireless providers to enter a market.

Under the Act, local municipalities retain general jurisdiction over the placement, construction, and modification of wireless facilities. Thus, the law is not, and was not intended to be, a complete override of local zoning authority. The Act does, however, restrict municipalities in some areas. For example, a municipality cannot regulate the placement, construction, or modification of wireless communications facilities on the basis of radio frequency emissions, so long as the radio frequency emissions from a given site comply with FCC regulations.

The Act qualifies local municipal zoning authority in several ways. A municipality may not unreasonably discriminate among carriers who provide functionally equivalent services—for example, PCS, cellular, and

ESMR. A local municipality cannot prohibit the provision of wireless services within the municipality, or through its actions or regulations have the effect of prohibiting the provision of wireless services. Some court cases under the Act have held that a municipality must act on a request to place, construct, or modify a wireless communications facility within a reasonable period of time after the application is filed.

In interpreting the federal law, some court cases have held that a municipality's decisions regarding requests for the placement of wireless facilities must be in writing and must be supported by substantial evidence that is contained in a written record. Many municipalities already followed this standard before the Act.

Lattice-type telecommunications tower with antennas of two wireless carriers. © LEONIE FOY

Finally, the Act gives carriers a remedy if the carrier is prohibited from placing, constructing, or modifying wireless communications facilities within a municipality. Carriers can take the local municipal decision to federal court and ask the court to review the decision on an expedited basis. The carrier has to bring an action within thirty days of the municipal decision. This right is in addition to any other state or local rights available to the carrier, such as legal appeals through municipal administrative processes, appeals to a state court, or appeals to designated state agencies.

HOW HAS THE ACT BEEN INTERPRETED?

Like any law, the Telecommunications Act does not take on life and meaning until is interpreted by municipalities and courts. What do these qualifications on municipal authority mean? Here's a summary of how the Act has been interpreted across the country, through the decisions of both federal and state courts:

Discriminating among providers of functionally equivalent services: Courts in various states and federal districts have generally agreed that municipalities cannot issue decisions regarding the placement, construction, or modification of wireless facilities that favor one carrier over another. For practical purposes, this means that in any situation where the facts are equal, a municipality cannot decide that one carrier can place a wireless facility and another cannot simply because the municipality looks more favorably upon one carrier than another.

A municipality cannot decide which carriers, or how many carriers, can offer service in their municipality and thus deny any other carriers the right to place, construct, or modify wireless facilities in the municipality.

Where there are differences in the applications for wireless facilities, the municipality can make decisions based upon those differences. These differences include location of the wireless communications facility, differences in the type of wireless communications facility proposed, or safety concerns. If a municipality allows a monopole in an industrial area, it does not necessarily have to allow a monopole in a residential area, even though the services provided may be functionally equivalent, because the location of the wireless communications facilities are different. In that same vein, it is proper for a municipality to place height restrictions on wireless communications facilities that are in different zoning districts, so long as the height restriction is not so strict that the wireless communications facility cannot work from a technical perspective.

Prohibition of wireless services: Courts have uniformly agreed that a municipality cannot enact a general ban on the placement, construction, or modification of wireless facilities, or enact bylaws or ordinances that have the effect of prohibiting wireless services. Municipalities can, however, enact limited moratoria on the placement, construction, or modification of such facilities for the purposes of studying how best to handle and process these applications and to

create a bylaw to address wireless communications facilities. Courts have held that moratoria of six months or less are considered reasonable. Courts have further held that it is not reasonable for a municipality to enact a series of moratoria.

Courts either have not addressed or are divided on the issue of whether other types of restrictions found in bylaws constitute a prohibition. Most courts addressing the issue agree that a municipality does not have to allow wireless communications facilities in all areas, but the courts disagree on when such regulation becomes a prohibition.

A court could hold that a municipality that limits the placement of wireless communications facilities to only industrial districts, when the municipality has very few industrial districts, has in effect banned the provision of wireless services. Similarly, a municipal bylaw that has a large setback requirement for wireless communications facilities in a municipality with only small lots may be found to be prohibiting the provision of wireless services.

Acting upon an application within a reasonable time: Generally, courts have held that municipalities can take the same amount of time to consider an application for a wireless communications facility as they would take for any similar type of facility. This means the municipality should comply with any state or municipal time frames already established. A municipality may take additional time to study an application as long as it follows the procedures it would ordinarily follow to obtain additional time, such as asking the carrier to agree to additional time. The Act is not meant to give wireless providers preferential treatment in the review of their applications, but to ensure that carriers receive the same treatment as other applicants.

Supplying written decisions supported by substantial evidence: "Substantial evidence contained in a written record" is the traditional standard used by courts when reviewing the actions of government agencies. Courts reviewing this standard under the Act have come to varying conclusions on what this means. Courts generally agree that a decision must be in writing, so an oral announcement of a decision by a municipality will not meet this standard.

The courts differ, however, as to whether the written decision must contain a statement of factual findings as is required under federal administrative law. Some courts have said that written findings of fact and conclusions of law must be issued by the municipality in order to satisfy the requirements of the Act. Other courts have held that a letter, stating that an application is denied, without any further explanation, is sufficient.

Courts also disagree on what constitutes substantial evidence. A majority of courts have held that generalized constituent opposition to the placement, construction, or modification of a wireless communications facility is not substantial evidence. Generalized opposition includes the perception that the placement of a wireless communications facility will lower the property values of adjacent properties, or vague assertions that a tower will be aesthetically displeasing. These considerations are not irrelevant to a denial of an application, but they should be supported by particularized objections to a proposed site.

While in unusual circumstances, federal district courts in the First and Second Circuits have found that a municipality violated Section 1983 of the Civil Rights Act when it denied an application for placement of a wireless communications facility, other courts have not agreed with those decisions. Proving a Section 1983 violation is a difficult task, but if proven, the carrier can collect costs and other damages.

Regulating based on radio frequency emissions: The Act clearly states that a municipality cannot regulate the placement, construction, or modification of a wireless communications facility on the grounds that radio frequency emissions are harmful if such emissions are in compliance with FCC regulations. If a wireless communications facility is in compliance with FCC regulations on radio frequency emissions, a municipality cannot deny an application on that basis. The courts agree that regulation of radio frequency emissions is solely the responsibility of the FCC. State and local regulation is preempted. Courts have held that constituent concerns about the health effects of wireless communications facilities cannot be the basis of the denial of an application. A municipality can ask for proof that the wireless communications facility complies with the FCC regulations, but the municipality may not impose monitoring or reporting requirements that are different from or more stringent than those required by the FCC. ■

How State Law Affects the Siting of Wireless Communications Facilities

Before the Telecommunications Act of 1996, siting decisions in the Commonwealth of Massachusetts were guided by the Zoning Act. Known today as Chapter 40A of the Massachusetts General Laws, the Zoning Act was enacted substantially in its current form in 1975. The purpose of the Zoning Act is to encourage the adoption and/or modernization of zoning ordinances and bylaws and to standardize the procedures for implementation of those ordinances and bylaws.

How the Zoning Act affects the ability of municipalities to condition or restrict the placement of wireless communications facilities is reflected in two distinct and materially different ways and sections:

1. Substantive and procedural criteria and standards for relief under the local zoning bylaw or ordinance *(Sections 6 through 17)*

2. Exemption from local zoning regulation *(Section 3)*

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CRITERIA FOR RELIEF

The Zoning Act directs and guides municipalities through zoning issues by providing strict administrative procedures for notices to abutters, public hearing processes, decision writing, and appeal processes. It also provides substantive standards to apply for the approval or denial of the four main types of zoning relief that a municipal permit granting authority/board may or may not grant within its discretion for the establishment of a wireless communications facility in its community: special permits, variances, site plan reviews, and expansions of pre-existing nonconforming uses.

Special permit: A special permit under Section 9 allows the use of land or certain structures for a special purpose upon the satisfaction of general and/or specific provisions and conditions set forth in the municipality's ordinance or bylaw. A special permit is granted only for uses that the municipality has determined are in harmony with the general purpose and intent of the zoning bylaw and allow the municipality discretionary power to allow, disallow, or to place conditions.

Variance: A variance under Section 10 may be granted only if it is found that: owing to circumstances relating to soil conditions, shape, or topography of such land or structure and especially affecting such land or structure but not affecting generally the zoning district in which it is located, a literal enforcement of the provision of the bylaw would involve substantial hardship, financial or otherwise, to the applicant, and desired relief may be granted without substantial detriment to the public good and without nullifying or substantially derogating from the intent and purpose of the bylaw.

Site plan approval: Site plan approvals are defined within a municipality's bylaw and typically address issues such as parking, traffic flow,

drainage, screening, lighting, and sewage disposal. These approvals are oftentimes dependent upon receiving a "by right" permit or a special permit for use and are generally meant to guide design features.

Section 6 finding: A finding to permit an extension of a nonconforming structure under Section 6 must include specific reference that the proposed extension or structural change complies with the bylaw or ordinance, or receive a variance from the particular dimensional provision, and reflect that the proposed changes are not substantially more detrimental to the neighborhood than the existing structure.

A finding to permit an extension of a nonconforming use under Section 6 must show that the intended use is substantially similar to the use in effect prior to the new bylaw taking effect, that the quality, character, and degree of use is similar, and that the proposed use is not different in its effect on the neighborhood.

Regardless of the specific type of zoning relief sought by an applicant, the courts have, as a general rule, shown considerable deference to local regulations and decisions. Denials by a local board will be sustained on appeal brought pursuant to Section 17 as long as the reason for the denial is within the standards of the zoning bylaw or ordinance and the Zoning Act, and so long as a board does not act in an "unreasonable, whimsical, capricious or arbitrary manner," or engage in any abuses of discretion.

Consistently, the courts have interpreted these standards relatively narrowly, giving the local authorities broad authority to regulate. Significantly, even if a board determines that all required conditions exist for the granting of a variance or special permit, it may exercise its discretion to refuse to issue the relief sought. Courts have repeatedly determined that for a judge to replace the board's discretion with his or her discretion would undermine the intended discretion given to the board by the Zoning Act.

EXEMPTION FROM LOCAL REGULATION

The Zoning Act in Section 3 limits the ability of a municipality to exercise its zoning authority over certain uses by providing that the Department of Telecommunications and Energy (formerly Department of Public Utilities) may, upon compliance with certain procedural requirements, exempt land or structures used by a public service corporation, in particular respect to the operation of a zoning ordinance or bylaw. The Zoning Act authorizes such public service corporations to seek authority for their use within a community directly from the DTE, rather than from the municipality.

The courts have delineated specific criteria for qualification as a public service corporation. For example, the applicant must be providing a necessity and convenience to the general public through ordinary channels of business; it must be subject to the requisite degree of government control; and the public must derive benefit from the service.

Between late 1980s and mid 1990s, approximately ten public service exemption petitions were filed with the DTE by wireless communications providers (several with the support of the municipality, which was confined by its own bylaw or ordinance). In each case, the DTE found that the wireless communications provider qualified for the exemption under Section 3.

In February 1996, the DTE, in its decision in *Dispatch Communications of New England* (DPU No. 95-59), held that wireless communications providers no longer qualified for the public service exemption. In a decision issued in January 1998, however, the DTE reconsidered its 1996 reversal and reaffirmed its previous position that wireless communications providers qualify as public service corporations that may be exempted from local zoning. This decision still stands.

It is significant to note, however, that the DTE emphasized that its review of zoning exemption petitions will in each case focus on whether "the interest of the general public has been appropriately balanced against the local interest." It further provided that its review will include whether the petitioner "has a plan to site facilities in an orderly fashion in its service area;" whether it considered existing towers and/or facilities; how much support or opposition is expressed by the municipality; whether efforts were made to find alternate, more acceptable sites; and whether steps were taken to address the concerns of the municipality and others. ■

Local Control and Municipal Concerns

The authority to control local zoning and land use is a power guaranteed to municipalities under state law and the Home Rule provisions of the Massachusetts Constitution. This system allows citizens to have input and influence over decisions that affect the quality of life in their communities.

It is also the case that the federal and state governments have imposed limits on the local zoning process in order to meet certain regional and national public policy goals. Relevant examples include the development of the infrastructure for the delivery of electricity and telephone service. In these instances, the state sanctioned the presence of corporate monopolies and assumed the authority to regulate them heavily.

In the 1990s and beyond, these same utilities are transforming into new corporate entities that operate in a competitive marketplace. This has created enormous pressure to alter federal, state, and local zoning policies to facilitate this transformation. Some see this pressure as an attack on community-based democracy. Others see the changes as necessary to allow consumers to access and benefit from innovations in telecommunications.

In the area of wireless telecommunications, this debate is taking place across the country in town halls, the courts, and state legislatures. The federal government has held that municipalities shall retain control over the siting of wireless facilities, but it has imposed some limitations on this authority. Communities cannot take actions that would effectively prohibit the network build-out, and they cannot discriminate between carriers. These standards have triggered much confusion, due in part to the many differences among land-use policies, population density, and topography in each community, and the differences between the marketing and build-out strategies of each carrier.

To some degree, the Federal Telecommunications Act has forced the industry to address the concerns of municipalities, but the demands of a competitive marketplace are also forcing each carrier to build its infrastructure as quickly, efficiently, and effectively as possible.

Increasingly, local officials are saying that the debate should not be about whether to impose strict limitations on local zoning powers in order to enable wireless service providers to meet their regulatory requirements. Rather, the goal should be to find solutions that enable host communities to ensure that their visual, aesthetic, and neighborhood impact concerns

Harvard Town Hall
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are addressed, while making it possible for the wireless industry to build out its infrastructure to meet the growing demands of its customers.

LOCAL DECISION-MAKING

Under state law and the Home Rule provisions of the Massachusetts Constitution, municipalities have the right to regulate and control land use. This local decision-making power is intended to prevent distant political bodies from imposing decisions that could be inconsistent with the interests of communities. The authority to regulate land use and implement zoning policy has been placed in the hands of those officials who are closest to and most accountable to local residents. Simply put, this system empowers local residents as the decision-makers who determine the quality of life for the communities in which they live.

The proposed placement of a wireless telecommunications tower in a community is often a quality-of-life concern for residents. Since federal law does not allow local governments to ban the siting of these facilities, the challenge is to establish a framework that protects the interests and rights of both localities and the industry. Such a framework must allow local officials enough latitude to act in a meaningful way to minimize the impact of the network build-out on the community and neighborhoods.

When negotiating with carriers, the question of where to locate wireless facilities is not the only issue but it is usually the largest. The location decision is a technical, zoning, and political issue rolled into one. It is technical in that each proposed facility needs to be located so that it fits in with the rest of the existing network, and each established site affects future build-out options. The topology of a community, the height of tree lines, the curves in the roads, and other factors determine the usefulness of each potential site. Fewer workable sites or greater geographic complexity generally result in proposals for taller structures.

> "THE GOAL SHOULD BE TO FIND SOLUTIONS THAT ENABLE HOST COMMUNITIES TO ENSURE THAT THEIR VISUAL, AESTHETIC, AND NEIGHBORHOOD IMPACT CONCERNS ARE ADDRESSED, WHILE MAKING IT POSSIBLE FOR THE WIRELSS INDUSTRY TO BUILD OUT ITS INFRASTRUCTURE TO MEET THE GROWING DEMANDS OF ITS CUSTOMERS."

The location decision is a zoning issue in that many communities have created overlay zones to try to predetermine the most agreeable locations. This may or may not have been done with the carriers' technical requirements in mind. An overlay district in the middle of an industrial zone situated in a valley may be of little or no use to the wireless carrier if its signal cannot reach the downtown district, where the bulk of the local wireless phone users are located. If this is the only option that a community has made available to carriers, then that community would be vulnerable to legal or regulatory action.

The location decision is also a political issue in that citizens frequently become active when they learn of site applications. Citizens may object due to fear of radio-frequency (RF) emissions, even though communities are not allowed to regulate based on health concerns. Or residents may be upset that a proposed facility would be visible from their back yard. Or they may be concerned that wireless communication towers could affect their property values.

Whatever the reason, citizens are turning out at zoning board hearings in large numbers. This makes it even more difficult for municipal officials, as they strive to stay within the limits of federal law. Municipal officials must communicate the limitations of the decision-making process to the public.

FINDING SITING SOLUTIONS

Local governments must make sure that they have a zoning process in place that is appropriate for the complexities associated with the siting of wireless communication facilities. This foundation often makes the difference between being stuck with a structure that is intrusive and negotiating a site that has the minimum visual impact and maximum economic benefit for the community. The key is having a process that is flexible enough to allow local decision makers to negotiate acceptable solutions.

Many of the early zoning bylaws

and ordinances that were created in response to the Telecommunications Act of 1996 were written with prevention in mind. Strict criteria were designed to limit the height, setback, or location of the structures in an attempt to avoid bad locations or oversized facilities. Carriers were forced to meet these strict criteria, settle for a gap in service, or appeal to the courts or the Department of Telecommunications and Energy to acquire approvals.

On the other hand, carriers have been reluctant to discuss site or design alternatives, even though they may have other options. There are many ways to engineer facilities and networks. For example, instead of one tall tower, it may be possible to deploy two shorter towers or monopoles at different locations. Two small towers outside an overlay district may be more desirable than the one tall tower in the middle of the district. Narrowly crafted bylaws or ordinances that block these workable solutions can be detrimental to community needs. There are several examples of communities and carriers jointly approaching the DTE to implement negotiated solutions that do not fit the criteria allowed for in local bylaws.

Historic districts are particularly challenging, since these areas are required to maintain the characteristics and appearances of a pre-electronic communications era. It is not enough to camouflage wireless facilities; they cannot appear to exist at all. Any facade that is used to conceal a wireless facility usually needs to be made of the same material as the original structure, which can cause signal loss problems.

Communities have a better chance of finding siting solutions if their bylaws or ordinances provide a great deal of flexibility regarding the location and conditions for facilities. A mutually acceptable agreement, as in any business arrangement, is best accomplished through direct communication and a fair and level process. Municipalities need enough negotiating leverage to keep carriers at the table to hear local concerns about each site. Appropriate siting solutions are best found through fair and direct negotiation between a municipality and the carrier seeking a permit.

UNDERSTANDING THE LAW, TECHNOLOGY, AND OPTIONS

Local officials must understand the limits established in the Federal Telecommunications Act. Many local officials have been led to believe that the law stripped away local authority. This is not the case. Although the law limits local authority in some areas, it specifically preserves local decision-making authority in the siting of wireless facilities. The law establishes a framework for the exercise of state and local zoning jurisdiction over the construction, modification, and placement of facilities. The courts have been endeavoring to define what municipalities can use as justification for denying site permits, and the issue is continually evolving with each new court decision. It is important for municipal officials to follow this court action closely.

In addition, municipal officials must understand enough about the technical aspects of wireless com-

Facilities located on the top of buildings can blend in with other structures already there.
© OMNIPOINT COMMUNICATIONS

munications technology to be able to identify available options for siting. Municipal officials do not need an engineering degree in communication networks, but they must understand the effects that height, power levels, and screening have on RF signals and the capacity of each facility to handle future demand. Cities and towns should consider using technical experts to develop bylaws or ordinances as well as to assist in negotiations with carriers.

Local officials should be aware of the many options available to minimize the visual impact of wireless communications facilities. The options include: co-location on existing towers, placing antennas on top of buildings, flush mounting on the side of buildings, and painting to blend facilities in with the décor of a building. Facilities located on the top of buildings can have RF-transparent screens to hide them from view. Some feel that monopoles are less harsh on the eye than lattice-style towers. There are also dual poles and flagpole designs. Monopoles are sometimes colored to blend in with the surroundings. Towers located in wooded areas have been effectively camouflaged as trees, which works well if the towers are not significantly taller than nearby trees. The most effective method for camouflaging a facility is to locate it inside an existing structure, such as a church steeple so that the facility is completely hidden from view.

> “SOME OF THE MANY OPTIONS AVAILABLE TO MINIMIZE VISUAL IMPACT INCLUDE CO-LOCATION ON EXISTING TOWERS, PLACING ANTENNAS ON TOP OF BUILDINGS, FLUSH MOUNTING ON THE SIDE OF BUILDINGS, AND PAINTING TO BLEND FACILITIES IN WITH THE DÉCOR OF A BUILDING.”

Even after agreements are reached and facilities are in place, communities must continue to communicate with carriers on a regular basis. As the demand for wireless services increases, the demand for sites will also increase. Knowing what is coming will enable local officials to act swiftly and certainly to safeguard the interests of their communities. Knowledge and flexibility are the keys to finding the right solution for each siting dispute. ■

Flush-mounted antennas at the top of the building are painted to match the brick. The equipment shelter/base station (lower right) is sided with masonry to match the stone walls and landscaping.

BELL ATLANTIC MOBILE

Municipal Leadership—Being Prepared

"Knock, knock." Sooner or later a wireless carrier will come calling, looking for a new site. Wireless technology is a key part of our growing economy and is here to stay. It will come to every municipality over the next few years. Communities that wait until there's a knock at the door will be forced to make difficult decisions with little time or information. Communities that have been preparing for the inevitable siting proposals will have the greatest chance of successfully safeguarding their interests and concerns.

Here are some of the many ways that local officials can make sure their community is prepared:

HAVE BYLAWS IN PLACE

Local officials should not wait for a permit to be pending before attempting to put together a thoughtful and reasoned bylaw. Soon after the Telecommunications Act was passed in 1996, many communities enacted moratoriums to give them enough time to update their bylaws to address this issue. As time passes, courts will not look favorably on moratoriums, so now is the time to act.

MAKE SURE BYLAWS ARE WORKABLE

When the Telecommunications Act was enacted, some communities wasted no time in developing bylaws or ordinances to deal with the new rules for the siting of wireless telecommunication facilities. These communities either formed citizen committees and/or hired consultants to assist in developing bylaws or ordinances to protect the community from a proliferation of telecommunications towers.

Many of these bylaws or ordinances were used as models by other cities and towns. In some cases communities even adopted the same language. There are dangers to this approach, however, since bylaws written for one community may not work in another. One size does not fit all. Before looking to use other models, communities must be sure that they have similar priorities and desired outcomes. If not, serious problems can result.

Bell Atlantic Mobile rebuilt the steeple on this church in the center of Ipswich to house telecommunications antennas. Nextel and Sprint PCS joined Bell Atlantic Mobile and are co-located on antennas inside the steeple. © KEN CARTY

DEFINE OBJECTIVES

Communities should define their objectives in advance. Some communities may decide that it is more important to ensure that there is money available to take a tower down when it is no longer needed, rather than ameliorating the visual impact of the tower. Some communities may prefer several shorter towers just over the tree line, while others may want one or two very tall towers. The community should determine up front what outcomes are most important.

At one extreme, many people want their bylaws to prevent the location of telecommunications facilities altogether. This approach usually results in costly court battles, with the community losing control over the final decision of how and where a wireless facility will be located. Another extreme is to allow wireless carriers to locate at any site they choose in

the community. Allowing the industry total control over siting decisions could avoid court battles, but may well ignite general community dissatisfaction and citizen unrest. Obviously, the only realistic option is to design and establish a process to balance both needs—to minimize the impact of siting proposals while allowing the industry to build communications networks consistent with federal law.

> "WHEN ENGINEERS SIT DOWN TO DESIGN A NETWORK, THEY MUST CONSIDER MANY FACTORS. IN GENERAL, EVERY COMMUNICATIONS NETWORK HAS SOME FLEXIBILITY."

Such a process requires a good-faith effort on the part of both parties and generally calls for a healthy dose of negotiation before reaching final agreement on siting proposals. These negotiations, which can be tense at times, require flexibility and some give and take. Sometimes no middle ground can be found. But, more often than not, solutions are possible.

BE FLEXIBLE

When an engineer sits down to design a network, he or she must consider many factors before determining which structures and which sites can connect into a carrier's communications network. There is usually more than one location or facility that will work in a given region. Carriers may prefer some options, but in general every communications network has some flexibility.

Being flexible is also an important ingredient in the recipe for success at the local level. There are many cases where communities have promulgated bylaws designed to protect them from a proliferation of telecommunication towers, but they found that the language does not afford them the flexibility to implement reasonable solutions or compromises. For example, a community bylaw that prevents towers taller than thirty-five feet, in an attempt to diminish any negative visual impact, will preclude a possible solution calling for a single 100-foot tower in a part of town that has little visual impact and may accommodate all of the wireless carriers that are applying for permits.

The single higher tower may be a better solution than attempting to force carriers to build multiple thirty-five-foot towers that may be too short to work anyway. Bylaws that do not allow municipal officials adequate flexibility usually force the industry to take legal or regulatory action to secure a permit.

TALK WITH INDUSTRY TO IDENTIFY LOCATIONS THAT WORK

Communities that are considering creating overlay districts must note that these districts should be reasonably suitable for both carrier network needs and the community. Communities that have brought in wireless carriers to help determine the best locations for an overlay district have had the greatest success with those districts. Identifying an overlay district that effectively prevents a network build-out because it is unsuitable is a wasted effort.

Even though carriers and engineers have some flexibility, they cannot make bad or unsuitable locations work. Municipalities should try to sit down with all the carriers and map out the community. Local officials can then review the areas and locations that work for the carriers and proceed to map out an area that may be acceptable to the community. If there are sufficient areas in common, a difficult task is done. If not, then discussions can begin to find siting compromises or other alternatives, such as hiding or disguising facilities.

UNDERSTAND THE TECHNOLOGY

Some knowledge of wireless technology is essential to understanding the possible siting options and solutions. There are many publications—including this one—that give an overview of the technology and the basics of what makes the wireless network work. This knowledge helps when developing bylaws or ordinances, and when negotiating with carriers.

UNDERSTAND THE TELECOMMUNICATIONS ACT

Study the various parts of the Telecommunications Act of 1996 that define the municipal responsibilities and role in the siting of facilities. Although the law provides communities with the ability to regulate the placement, construction and modification of personal wireless service facilities, there are restrictions as well. The most prominent and controversial is the preemption of any ability

to regulate based on perceived environmental effects of radio-frequency emissions. It is vital that local leaders know what the law states firsthand.

Antennas can be flush-mounted on the sides of buildings and painted to blend in with the building's décor. © OMNIPOINT COMMUNICATIONS

FOLLOW SIGNIFICANT COURT CASES

The text of the Telecommunications Act may not be the only word. The Act's interpretation by the courts has helped to further define the role of local government. Local officials should consult with their town counsel or city solicitor, or with special counsel, in order to become familiar with the precedent-setting cases. In some recent decisions, the courts seem to be providing more latitude to communities. This could have the effect of encouraging the industry to compromise on alternative locations or agreeing to minimize negative aesthetic impacts. Again, this is evolving, and municipal officials need to be aware of the relevant decisions on an ongoing basis.

DON'T HESITATE TO NEGOTIATE

Once local officials have done all of this work to prepare for the knock at the door, they should relax. There's nothing to be afraid of. While the carriers are interested in building their networks and competing in this new industry, local officials are simply trying to do what is best for their neighborhoods and residents. Armed with good bylaws, knowledge of the industry, and a clear set of community objectives, local officials can have a great deal of influence over the siting of wireless facilities.

CASE STUDIES

There are many examples of successful agreements between communities and wireless telecommunications carriers. In most of these cases, successful negotiations resulted from advanced planning by the communities and cooperation from the carriers. Open communication between the communities and the carriers was essential, and each party was willing to consider solutions that met the needs of the other.

BRIDGEWATER

The town of Bridgewater approached Sprint PCS and negotiated an agreement under which the carrier would repair a church in the center of town that had been badly damaged in a fire. The church was rebuilt, including a new steeple, with a wireless facility hidden inside the steeple. The facility was designed to accommodate the co-location of two additional antennas. A variance was approved after a site plan review was conducted. In this case, there was overwhelming support for the siting and construction of the wireless facility.

There are other wireless towers in the town that do not have as much popular support. The first tower was approved through a special permit that had few restrictions. The tower now has numerous co-located facilities attached to it, which, according to the town, have a negative visual impact on the area.

The most recent facility is a monopole that requires approval from the town before more facilities can be co-located. This allows the community to moderate the visual impact of the towers. The town has a bylaw that addresses the siting of towers, but it does not have a bylaw specific to wireless communication facilities. A special permit is required from the Planning Board in order to site a wireless telecommunications tower.

IPSWICH

Bell Atlantic Mobile approached a local downtown church that had removed its steeple 20 years earlier and offered to reconstruct the steeple if the church would allow the company to locate a wireless facility inside. At the time, the town did not have a bylaw specific to wireless telecommunication towers, and therefore sent the proposal to the Zoning Board of

Appeals for a use variance. The proposal was supported by the town's residents, especially by public safety officials and members of the Historic Commission. Nextel Communications and Sprint PCS have since co-

> "ARMED WITH GOOD BYLAWS, KNOWLEDGE OF THE INDUSTRY, AND A CLEAR SET OF COMMUNITY OBJECTIVES, LOCAL OFFICIALS CAN HAVE A GREAT DEAL OF INFLUENCE OVER THE SITING OF WIRELESS FACILTIES."

located on the facility.

The town then created a bylaw specifically for the siting of wireless facilities. The bylaw was designed to encourage carriers to locate facilities inside, attached to or on existing structures. The bylaw established a by-right process within certain districts for facilities to be constructed inside an existing structure. The bylaw also created a by-right process with a site review plan for proposals to attach antennas to existing structures or to affix them not more than fifteen feet above the top of a building. All requests for wireless communications towers must go through a special permitting process.

With the assistance of the carriers, the town created an overlay district. All carriers were invited to a meeting to provide input regarding their facility needs and plans. The town used this information in determining the parcels to be included in the overlay district.

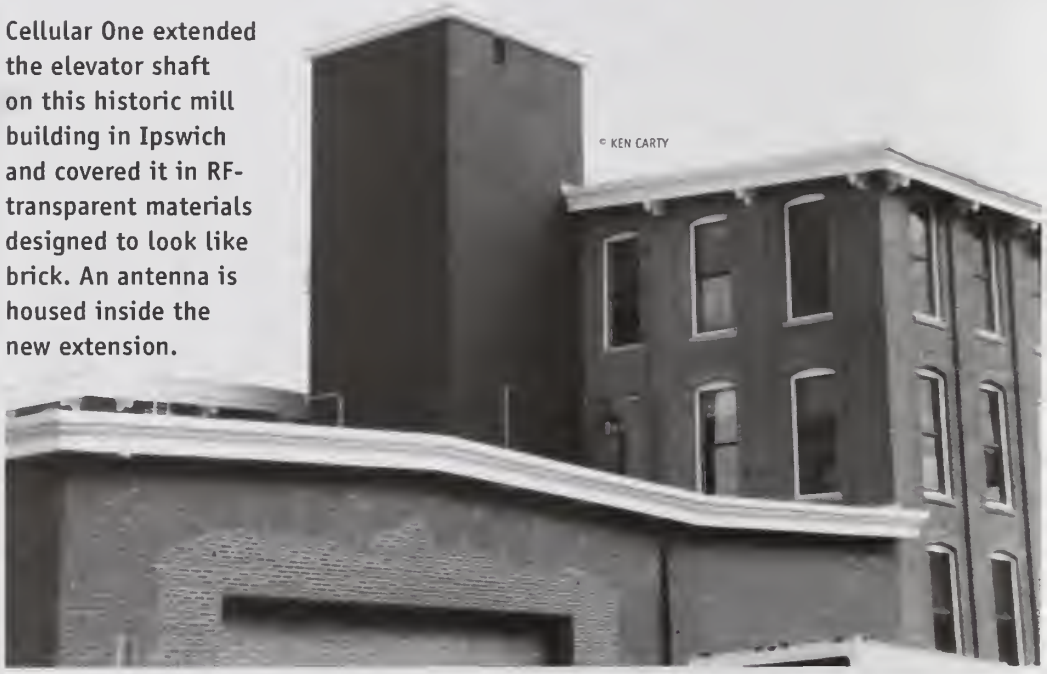
The town has issued three permits for freestanding wireless facilities. An Omnipoint Communications antenna will be located on one of the poles supporting the netting for a golf driving range near Route 1. Another Omnipoint wireless facility on Route 1 will be located on a 55-foot utility pole. A third permit was issued for a Cellular One facility that will be located inside the elevator shaft of a historic mill building downtown. A site plan review was conducted in that instance because the design called for the shaft of the building to be extended in height and improved in order to provide sufficient height for the tower.

The bylaw, which received overwhelming support from Town Meeting in October 1997, has worked well.

STURBRIDGE

The town and Sprint PCS were involved in a long-standing disagreement over the siting of towers at two separate locations. Sprint PCS had brought the town to federal court over the first site, but then decided to withdraw that court proceeding and file with the Department of Telecommunications and Energy for a permit to locate both towers in the community. During the DTE proceedings, DTE staff encouraged both parties to negotiate an agreement outside of the formal proceeding. The town and Sprint PCS were able to reach an agreement for both sites. The agreement could not be implemented following the town's bylaws, however, so the town and Sprint PCS agreed to jointly petition the DTE to rule in favor of the compromise agreement, thus overriding the town's bylaws.

After reviewing its options, the



Cellular One extended the elevator shaft on this historic mill building in Ipswich and covered it in RF-transparent materials designed to look like brick. An antenna is housed inside the new extension.

AT&T Wireless Services constructed this wireless communications tower camouflaged to look like a white pine tree in the town of Harvard. © KEN CARTY

town had determined that its greatest concern was to ensure adequate funds to remove the towers when they are no longer needed. The town also wanted as few towers as possible, so the town required that each monopole be tall enough to support up to six carriers. The town decided that these issues were more important than trying to force Sprint PCS to move the towers to other locations.

Once the town had determined its priorities, an agreement was then possible. Most of the citizens in the town considered the agreement to be reasonable and avoided the continuation of a costly legal battle.

HARVARD

The town of Harvard established a committee to develop its bylaws. The committee set as its goal the minimization of any visual impact caused by wireless telecommunication towers sited in the community. One of the members of the committee had seen a tower in Pennsylvania camouflaged as a tree and then obtained additional information on the camouflaging of wireless communication towers. The committee included a provision in the bylaw to encourage camouflaging. Applications were received from AT&T Wireless Services and Nextel Communications. Both carriers agreed to camouflage their respective towers as pine trees.

These monopoles are designed to rise slightly above the trees and each is disguised to look as if it is the tallest pine tree in the area. The town made the decision that it would rather have several smaller camouflaged towers in town than one tall tower with all carriers attached. ■

Creating a Bylaw for Wireless Communications Facilities

The process begins. Maybe it is the first application your municipality has received to build a wireless communications facility and you are trying to figure out how to handle it. Maybe it's the fourth or fifth application, and prior attempts at reviewing the applications have been difficult. Or, maybe you have watched adjoining municipalities struggle with applications for wireless communications facilities and you would like to avoid those problems in your municipality. What can you do to make the process less painful and still meet the needs of your municipality? One of the best things to do is to have a clear, consistent bylaw in place that addresses the placement, construction and modification of wireless communications facilities. This article describes how to draft a bylaw that will comply with the law and get the best results for your municipality.

FORM A TEAM

Drafting a wireless communications facilities bylaw is a multidisciplinary process. You need an elementary understanding of the technology involved, an understanding of current federal and state law and how it affects wireless services, and a good understanding of your municipality. There are several key people to have on your team.

You need a representative from the public works department, who can talk about municipal property—where it is and what's on it—as well as major roadways in the municipality.

Antennas installed by Nextel are almost unnoticeable on this light stanchion at Fenway Park in Boston.

© NEXTEL COMMUNICATIONS

It's a good idea to engage competent land-use counsel to assist in drafting the bylaw and to advise you on the state and federal laws regarding wireless communications facilities. This is probably not something your municipal counsel can do; it requires the skills of someone who works with these types of facilities on a regular basis. Check with other municipalities to see whom they use and ask a wireless carrier for suggestions.

Get some technical engineering advice. This does not have to be very involved, but you should find someone competent in radio frequency engineering to explain the rudiments of wireless technology. There are many good engineering firms that can come in and do a presentation, as well as many resources at local colleges and universities. It also helps to have one or more of the wireless carriers come in and make a presentation about their network operations. The presentation will give you an understanding of the carrier's operational needs and will allow you to begin to think about how best to mesh the technical needs with your community's needs and concerns.

REVIEW THE LAW

The next step is to sit down with your attorney and review state and federal laws pertaining to siting wireless communications facilities. Does state law limit what your bylaw can do? Does it set time frames in which decisions must be made? Does it dictate who makes those decisions? How will the Telecommunications Act affect what you want to do in your bylaw?

Finally, take a look at your current bylaw. How does it address wireless communications facilities? Are there things that have worked well in the past? If so, incorporate them into the new bylaw. Are there areas that have caused concern? If so, analyze why this is the case and try to address those areas.

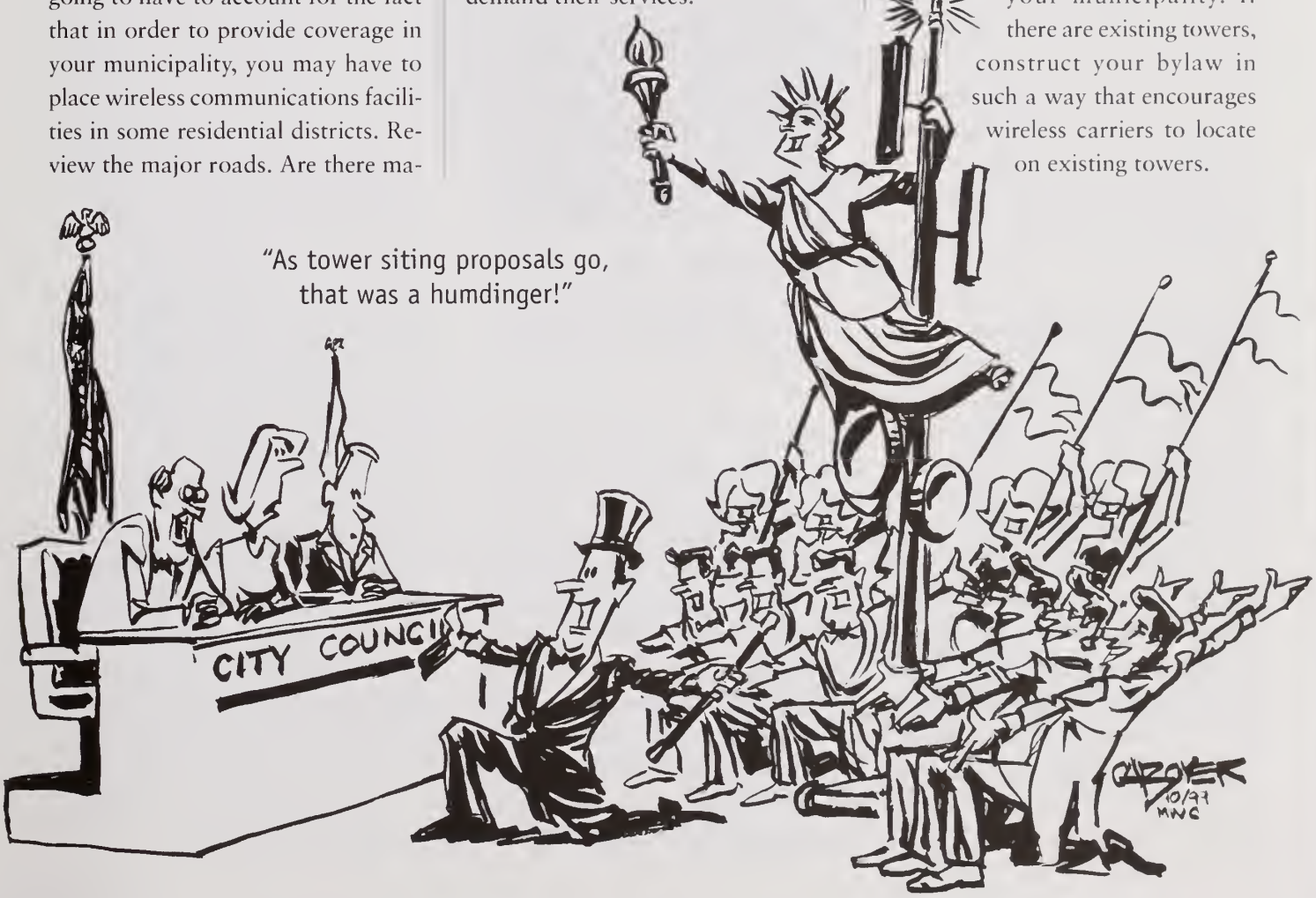
REVIEW YOUR MUNICIPALITY

Sit down with your public works representative and a good, recent map of your municipality. What does your municipality look like? Review the zoning districts and determine which districts are where. If your municipality is largely residential, you are going to have to account for the fact that in order to provide coverage in your municipality, you may have to place wireless communications facilities in some residential districts. Review the major roads. Are there major highways that run through or intersect in your municipality? Wireless carriers try to cover major roadways first and will be looking to place wireless communications facilities near those roads. Are these roads state or federal highways? If so, does your state have a mechanism to allow wireless carriers to site on rights-of-way near state highways? Encourage wireless carriers to use state property.

Review the major industries in town. Do you have large industrial parks? Any heavy industry? Many times it is easier to encourage carriers to site in industrial or commercial districts, especially if there are industries or businesses there that demand their services.

Inventory municipal property. See where it is and what it consists of. If municipal property satisfies a wireless carrier's coverage needs, it can also provide a good revenue source for the municipality. Does your municipality have any existing police or fire communications towers? Can they hold wireless communications facilities, or can they be replaced with a stronger tower that can hold both wireless communications facilities and police and fire equipment? Replacing such a tower can be a win-win situation for both the wireless carrier and the municipality.

Inventory existing wireless communications facilities in your municipality. If there are existing towers, construct your bylaw in such a way that encourages wireless carriers to locate on existing towers.

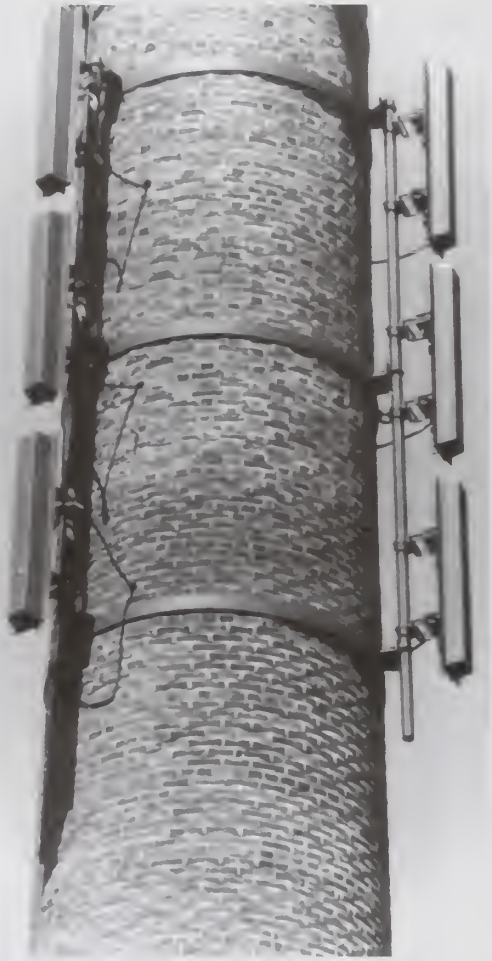


Review the geography of your municipality. Is it flat, hilly, or both? What is the average tree height? Keep in mind that most wireless technology has to clear the tree line to be effective and that barriers like hills and thick trees can block the radio signal. These considerations are important if you are considering height limitations for towers or monopoles.

Review the architecture in your municipality. Do you have many tall buildings (over sixty feet), water tanks, utility transmission towers, or church steeples? Wireless communications facilities located on these structures tend to be less visible and therefore less intrusive. Write your bylaw in such a way to encourage wireless carriers to use these structures whenever possible, keeping in mind that large structures and natural features can block radio signals and must be taken into account when determining suitable sites.

WHERE SHOULD WIRELESS FACILITIES BE LOCATED?

Once you have reviewed the law and your municipality, you should decide where you want new wireless communications facilities to be located. You need to balance the wireless carrier's need to provide coverage with what you are comfortable with in your municipality, all within the confines of applicable laws. Wireless carriers have the right to provide coverage to your municipality. The carriers are also facing tremendous demand for coverage that mimics landline coverage. Additionally, municipalities cannot prohibit the provision of wireless services and cannot discriminate among providers of functionally equivalent services.



A brick factory chimney provides a tall and sturdy structure for mounting antennas of multiple wireless carriers. © NEXTEL COMMUNICATIONS

The best way to meet all these needs is to create a process that encourages wireless carriers to first consider sites favored by your municipality. The process should require wireless carriers to provide additional information if a chosen site is not approved by the municipality. For example, if the municipality wants to encourage wireless companies to build sites only in industrial zones, it makes sense to create an easier process to place sites there. If the municipality has sufficient tall buildings or existing structures and wants to encourage wireless carriers to place wireless communications facilities on those structures, a simplified or even by-right type of process will accomplish that. If the municipality wants fewer large, multiple-carrier wireless communications facilities, or if it wants many smaller ones, it can encourage this through its bylaws. For example, siting on existing structures can be accomplished through an expedited approval process. If a municipality wants to encourage co-location, then it may allow taller structures for multiple use. Use bylaws to provide an incentive in order to encourage the desired type of siting.

PUT PEN TO PAPER

At this point, it is time to draft your bylaw. Keep it simple. Separate wireless communications facilities by type—those requiring new towers or monopoles versus those that can be placed on existing structures. Create a process for each type of wireless communications facility. It may make sense to create an expedited or even by-right process for wireless communications facilities that can be located on existing structures. Wireless communications facilities that require a new tower or monopole should have a more involved process.

The following are some recommended do's and don'ts:

DO'S

- Make sure you define relevant terms in your bylaw. Doing so will prevent confusion and disagreement once the bylaw is in effect.
- Encourage co-location on new towers and monopoles. If a wireless carrier needs to build a new tower or monopole, make sure it can hold at least one other carrier. Keep in mind that there needs to be space between carriers, so new towers and monopoles will need to be somewhat taller in order to accommodate more than one carrier.
- Require each new tower or monopole to have access from a public road or through an adequate easement.
- Require each new tower or monopole to be landscaped to screen the foundation and the equipment building from abutting properties.
- New towers or monopoles should be subject to reasonable setback requirements, but the requirements should not be so onerous as to prevent the wireless carrier from constructing a site in your municipality. For example, if your municipality is made up of smaller lots, you run the risk of violating the Telecommunications Act if you require the carrier to lease a large parcel to meet the setbacks and such large parcels are not available in the municipality.
- Require the wireless facility, if it is a new tower or monopole, to be surrounded by a fence of sufficient height to prevent unauthorized entry.
- Although legally governed by the state building code only, a bylaw may ask for evidence that the new tower or monopole meet the current structural standards for steel antenna towers and antenna support structures published by the Electrical Association/Telecommunications Industry Association.

"YOU NEED TO BALANCE THE WIRELESS CARRIER'S NEED TO PROVIDE COVERAGE WITH WHAT YOU ARE COMFORTABLE WITH IN YOUR MUNICIPALITY, ALL WITHIN THE CONFINES OF APPLICABLE LAWS."

- Any wireless communications facility may be required to comply with the FCC standards on radio frequency emissions, but communities cannot regulate those emissions; that is solely the province of the FCC.
- Give the municipality the flexibility to change height or setback requirements in those situations where it makes sense in order to create the best location for a wireless communications facility.
- Once the bylaw is drafted, seek input. Ask a wireless carrier to review it and give you feedback. Ask for citizen input. Review all the input carefully and keep in mind that sometimes this becomes an emotional issue. Try to get all parties to focus on the facts and doing what is best for the municipality, given the current state of the law and technology.

DON'TS

- Don't fall into the situation where your bylaw seems to provide for many suitable locations for wireless communications facilities, but when these locations are measured against the unique features of your municipality, such as the zoning districts and geography, in practice there are only limited locations available. A good example of this is a bylaw that says wireless communications facilities can be located by right in all industrial areas in a municipality, yet the municipality is ninety-eight percent residential.
- Don't require unreasonable fall zones. Wireless communications facilities supported by towers or monopoles are designed to fall into themselves, not topple over from the base. When built to the proper industry standards, the towers and monopoles are as safe as any other properly constructed structure.
- Don't set unreasonable application fees. Application fees should be the same as for similar applications and based upon the length and depth of review provided.
- Don't request so much technical information or try to regulate the engineering to such a degree as to leave your community open to litigation and with mounds of information that may be difficult to process. ■

How Wireless Technology Works

By Christine A. Malone

Knowledge of how wireless technology works and of its physical limitations makes it easier to understand the requirements of siting wireless facilities in the build-out of the telecommunications companies' networks and should help local governments craft better solutions for their communities.

SOME DEFINITIONS

Let's start with some basic definitions:

RF is the abbreviation for radio frequency. It is the portion of the electromagnetic spectrum that is above sound and below light. Television, AM and FM radio, Citizen Band radios, cordless telephones, and cellular devices all operate by using different portions of the RF spectrum.

The Federal Communications Commission (FCC) is the federal agency empowered by Congress to regulate the U.S. communications industry: wireline, wireless, broadcast (radio and TV), and certain aspects of the Internet. The FCC designates different portions of the RF spectrum for different purposes. It licenses certain frequencies to be used for various types of wireless communications services all over the United States. Just as FM radio stations are licensed to broadcast on a certain frequency in a particular area, wireless communications companies are licensed to use particular frequencies for a specified purpose over a specified geographic area. The type of wireless services a commercial mobile service company may provide is generally defined by the terms of its FCC license.

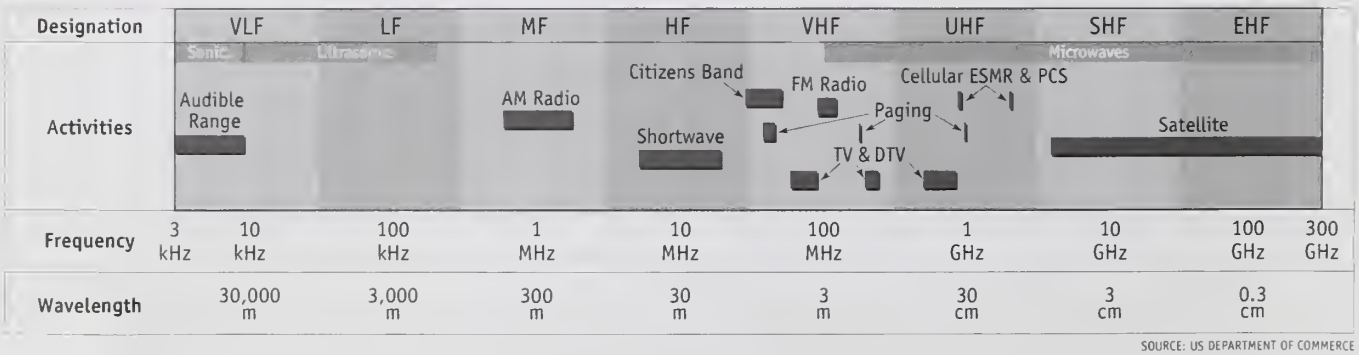
Frequencies are measured in Hertz (Hz), which are cycles (oscillations) per second. The most commonly used units for describing RF are the megahertz (MHz) and gigahertz (GHz). FM radio operates in the range of 88 to 108 MHz, broadcast television from 54 to 216 MHz (channels 2-13) and 470 to 806 MHz (UHF channels), and commercial and public wireless communications services at about 800 to 2000 MHz (0.8-2 GHz).

A number of different kinds of wireless service providers, also known as wireless carriers, are commonly, but not always accurately, described as "cellular" companies. The main types of commercial mobile services (or "wireless" services) they provide are described below.

The term "cell phone" is frequently used to refer to what are more accurately called mobile phones, which are distinct from the cordless phones commonly used in homes. And "cell tower" is a common term for describing a wide range of wireless communications facilities. With the incorporation of wireless information services such as e-mail and Web-browsing into mobile phones, the term "phone" may soon be outdated. These multipurpose voice and data units are currently referred to simply as "wireless devices."

A site (or "cell site") is another name for a single, complete wireless communications facility. It is more than just a tower; in fact a site may not have a tower at all. The main com-

Figure 1. The RF Spectrum



SOURCE: US DEPARTMENT OF COMMERCE

Table 1. Service Types, Operating Frequencies, and Carriers

SERVICE TYPE	FREQUENCY RANGES	EXAMPLES OF CARRIERS
Paging	35, 43, 152, 158 and 931 MHz	SkyTel
Cellular	824–849 and 869–894 MHz	Bell Atlantic Mobile, Cellular One
ESMR	806–824, 851–869, 896–901 and 935–940 MHz	Nextel
PCS-Wideband	1850–1990 MHz (1.85–1.99 GHz)	AT&T Wireless, Omnipoint, Sprint PCS
PCS-Narrowband	901–902, 930–931, 940–941 MHz	

ponents of a site are: the antenna(s) to transmit and receive the wireless signals, the associated equipment (computers, power supplies, etc.) to run the facility and process the signals, and the connection(s) to the local cellular switch. As these antennas generally need to be located high above the callers they are to serve, if there is no existing tall structure (such as a building, water tower, etc.) on which to place the antennas, a purpose-built structure is needed. This is usually some sort of tower, in which case the tower would also be a component of the site.

In order to reduce confusion, it is important to be precise in one's terminology—site, tower, etc.—when talking or writing about the issues of wireless facilities. There was a court case where a community had implemented an ordinance for "cellular towers," and a service provider successfully argued in court that theirs was not a cellular tower but a PCS tower (see definitions of Service Types below) and, therefore, not covered by the ordinance.

SERVICE TYPES

As described earlier in this publication, the first large-scale public wireless communications systems in the U.S. were for paging, starting in the early 1970s. In the mid-1980s, the FCC began awarding licenses for cellular service. The FCC has also licensed one or two companies to provide Enhanced Specialized Mobile Radio (ESMR) service, which has traditionally been used for fleet two-way dispatch communications but is now also being used for digital wireless phone service. More recently, beginning in 1993, the FCC has been auctioning up to six Personal Communications Service (PCS) licenses per geographic area throughout the country. And there are early plans for licensing other pieces of the RF spectrum for other emerging wireless applications. As a result, there could eventually be ten—or even more—companies operating wireless communications networks in a given geographic area.

> "IN ORDER TO REDUCE CONFUSION, IT IS IMPORTANT TO BE PRECISE IN ONE'S TERMINOLOGY—SITE, TOWER, ETC.—WHEN TALKING OR WRITING ABOUT THE ISSUES OF WIRELESS FACILITIES."

The original cellular networks carried analog signals. In recent years, many of these systems have converted to digital service. Digital cellular operates at the same frequencies, and under the same license, as analog cellular, but the signal is encoded in a different manner. Digital systems typically carry more calls simultaneously than analog, making them more cost-effective, and allow for added customer features like caller ID and voice-mail notification. This makes digital cellular more competitive with PCS and ESMR, which have been digital since their inception.

Although all of these systems—PCS, ESMR, and cellular—operate in essentially the same way from the customer's perspective, there are differences at the technical level that affect system design.

At a very technical level, types of wireless services can be further classified according to the technology used to manage calls and signals. Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), and Global System

for Mobile (GSM) are the most common technologies in the U.S. today. Others will likely emerge with the advent of wireless data and other services in the future. These distinctions are not usually important when it comes to tower siting, but you may hear these terms used.

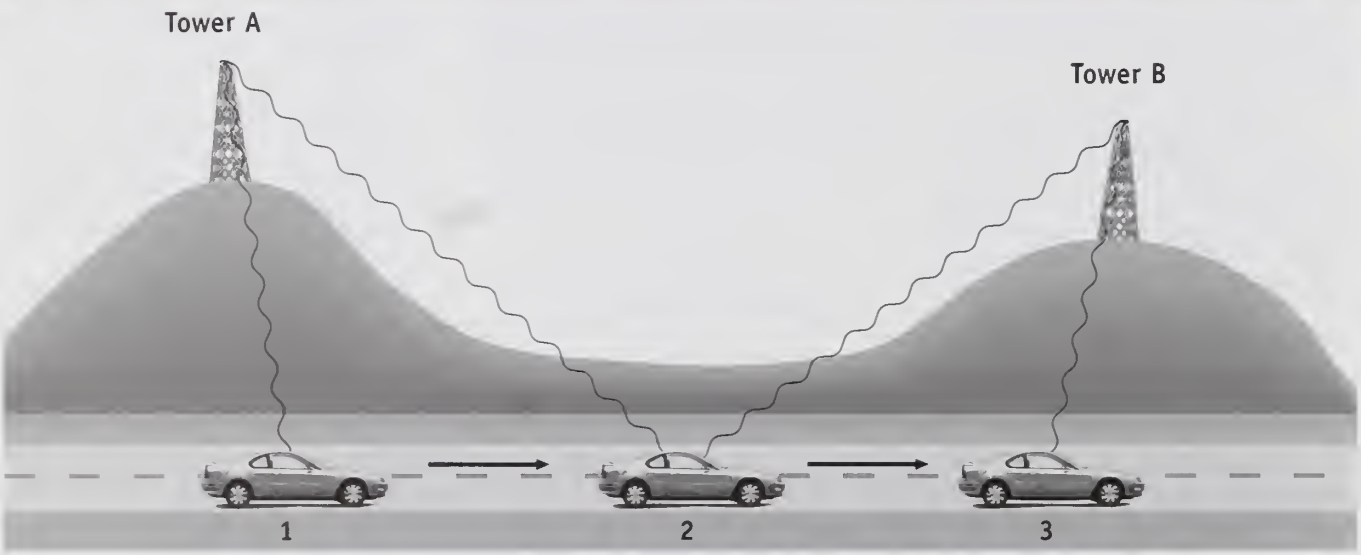
Lastly, another class of wireless service is satellite-based services. These services use satellites instead of towers or other structures to carry their antennas and relay signals (e.g., calls) to and from the users on the ground. (Earth-based systems as a group are sometimes called "terrestrial wireless.") Iridium and GlobalStar are satellite-based services, as are some of the national paging services, such as SkyPage. Satellite services are complementary to terrestrial services and can serve remote areas, such as mountain tops, deserts, and oil rigs, that are not easily or economically served by terrestrial wireless. They will not, however, replace terrestrial wireless.

RF PROPAGATION AND TRANSMISSION FUNDAMENTALS

Cellular, ESMR, and PCS operate by sending (or transmitting and receiving) RF signals between a stationary antenna (the "site") and a mobile unit (e.g., a wireless phone), which also has its own small antenna. The transmitted signal travels by spreading out through the air, or propagating, from the source antenna—either the stationary antenna or the mobile unit—and it is received by the other antenna. These signals travel in both directions between the site and the mobile unit when a call is in process. This is called a bi-directional or duplex system, unlike commercial radio or TV, where the signal travels only one way from the station to the listener or viewer. Until recently, paging was also a one-way system, where the stationary antenna only sent messages and the pager only received; but, with the advent of two-way paging, some of these paging networks have been reconfigured to both transmit and receive.

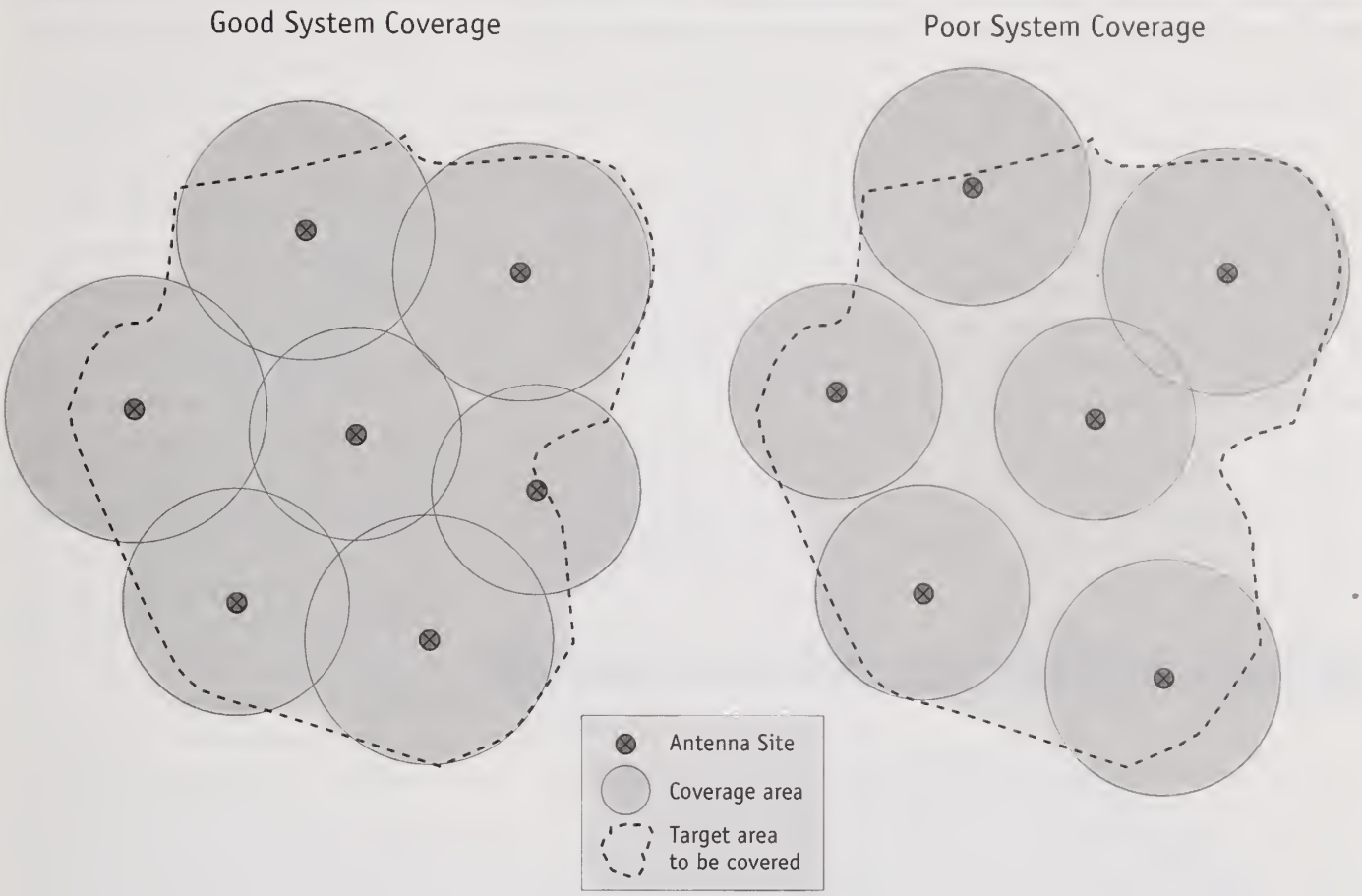
RF waves transmitted from an antenna decline in strength, or attenuate, as they travel farther from the transmitting antenna. Therefore, any one antenna can cover (transmit and receive signals for) only a limited geographic area, often called the range

Figure 2. Call Hand-off between Sites



The phone in the car at position 1 is "talking with" Tower A. As the car approaches position 2, the phone begins to pick up the signal from Tower B. Tower A and Tower B "talk with" each other and decide who has the best connection with the phone in the car. As the car approaches position 3, Towers A and B have agreed that Tower B has the better connection, and Tower A instructs the phone in the car to begin "talking with" Tower B and drop its connection to Tower A. The call itself continues without interruption.

Figure 3. Comparison of Good and Poor System Coverage



or coverage area of that antenna. This is the same principle that causes you to lose a radio station as you drive farther away from its source. Higher frequencies attenuate more rapidly over distance than lower frequencies.

A higher power, or stronger, signal will typically travel a greater distance from the source antenna. Transmission power levels are limited by the FCC and by system designers for a variety of reasons, including safety concerns and to reduce interference with other RF signals.

Unlike radio, where the transmitted signal is picked up by all receivers (radios) tuned to receive its frequency (called broadcasting), cellular, ESMR, PCS, and paging signals are coded in such a way that, even though a signal may be sent out in all directions, only the device that is programmed to receive it will recognize the signal. This is how your mobile phone receives only calls to your number and not calls to all phones in your area.

For wireless communications, there are generally multiple stationary sites in a geographic area. As the mobile unit travels from the proximity of one site to the next—by driving down the highway, for example—it is "handed off" by the system from one site to the next. The coverage of one site should overlap the coverage of the neighboring site to facilitate this hand off. If there is no overlap, the call will be "dropped" as the mobile unit leaves the coverage area of one site without being close enough to be "picked up" by the next, and the caller will be disconnected.

SYSTEM DESIGN ISSUES: COVERAGE AND CAPACITY

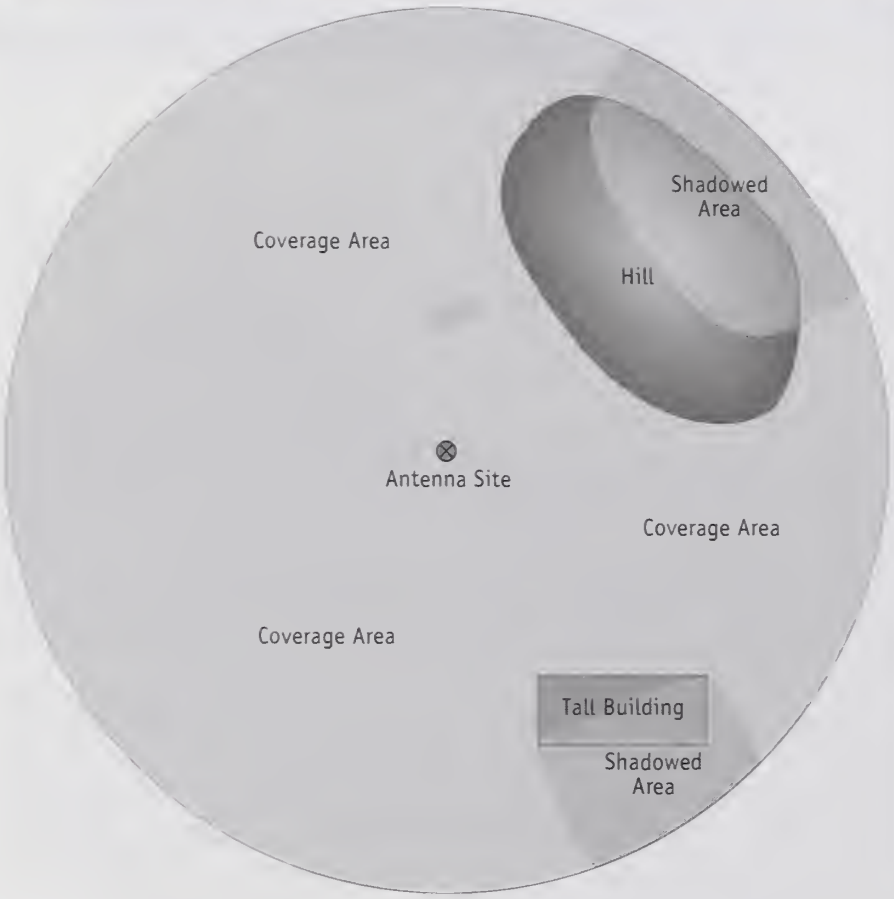
The issues that must be addressed by a service provider when its system is in the design stage are single-site coverage and system coverage. For example, if each cell site can provide coverage for ten miles in all directions and the sites are twenty-five miles

apart, there is at least a five-mile coverage hole in the system. Each site may be providing excellent coverage within its ten-mile radius, but outside that limit there is no coverage. This is a simple example of good single-site coverage but poor system coverage. The goal of the system designer is to design a network where the aggregate coverage of all the single sites provides the required system coverage. The ideal network looks like a honeycomb, where each site and the area it covers represents a "cell" and with adjacent sites providing seamless (unbroken) coverage over the extended area.

Cell sites rarely, if ever, provide such geographically symmetrical coverage. The real world presents too many problems to an RF signal trying to propagate from its transmitting antenna. RF signals used for cellular, ESMR and PCS are "line of sight" signals (i.e., they don't travel well through physical objects such as buildings or hills). This is easiest to understand by comparing RF signals to light. If a room is devoid of objects such as furniture, the best way to light it is with a tall lamp in the middle.

If the room contains objects, it can still be lit from the center, but now there will be shadows in some locations. More light sources may be needed to provide good illumination throughout the room. Similarly, if an antenna is placed next to (and lower than) a nearby hill, then there will be poor coverage from that antenna on the far side of the hill. An additional site might be needed to provide a strong enough signal in that area.

Figure 4. Showing Light/Signal Source and Shadowing



Height is a very important consideration in radio communications. The height of a site, as a combination of ground elevation (above mean sea level [AMSL]) and the structure height (above ground level [AGL]), must be high enough to provide the necessary coverage. To understand this, think again of the light example with objects (furniture) in the room. If the source of light is a twelve-inch high lamp placed on the floor, there will be many shadows.

For example, the area on the opposite side of a chair will have a shadow. If on the other hand, the light source is a ceiling lamp hung in the center of the room, there will still be shadows, but they will be contained to perhaps smaller and less important areas of the room. For the chair example, the shadow will now be under the chair. Imagine the difference when trying to read a book while sitting on a chair. The lamp on the floor will make this task very difficult, since the source of light is below the book and the back of the book will block the light, while the ceiling lamp will improve the readability drastically.

Obstacles in the real world are not pieces of furniture. And the shadows they create are much more irregular in shape and harder to design around. These obstacles include mountains, trees, buildings, cars, trucks, water towers—in short, any-

thing that stands between the transmitting antenna and the mobile unit. Considering these obstacles, it is obvious why height is so important for an antenna site.

When designing a network for a city, the sites should be higher than the surrounding buildings or there will be too many shadows, the signal will be severely impaired, and customers will not be able to make or receive calls in those areas. Similarly, if the obstacle is a mountain, the site should be above the mountain and be able to "see" the desired coverage location. For the RF system designer, height is one of the most significant design tradeoffs: there will always be shadows, the art is to increase the height to force the location of those shadows to less important coverage areas.

Location is also very important in RF system design. If you wish to provide light to an entire room for reading purposes, you would obviously choose to locate your light source in the center of the room rather than one of the corners. If the center is not available, the best way to light the room is probably to place lamps in different parts of the room, for example one table lamp on each side of the room. A person walking across the room looking for something on the floor will be using the light from lamp "A" on one side of the room and the light from lamp "B" on the other side of the room. Somewhere in the middle of the room, this individual will switch from using predominantly the light from lamp "A" to the light from lamp "B"; this is the hand off.

The final issue with system design is capacity. This is the amount of radio traffic, or number of calls, a wireless system can handle simultaneously. Radio spectrum is a finite quantity and can carry only a finite number of calls at once. A single site has only a finite number of channels that can handle calls. As more customers in an area subscribe to the service, the service provider must add more channels by adding more cell sites to the network. These new sites are usually interspersed with the existing sites, with each using its frequencies over a smaller geographical area, so that the system as a whole can carry more calls simultaneously. And because these sites now need only cover a smaller geographic area, they can be made smaller (closer to the ground) and their power can be reduced.

> "WHEN DESIGNING A NETWORK FOR A CITY, THE SITES SHOULD BE HIGHER THAN THE SURROUNDING BUILDINGS OR THERE WILL BE TOO MANY SHADOWS, THE SIGNAL WILL BE SEVERELY IMPAIRED, AND CUSTOMERS WILL NOT BE ABLE TO MAKE OR RECEIVE CALLS IN THOSE AREAS."

SERVICES CURRENTLY BEING BUILT OUT

The build-out for paging networks is pretty much complete, but the systems for all the other kinds of terrestrial wireless services are still in the rapid build-out phase. This build-out, and the resulting need for new sites, is likely to continue for another two to five years at least.

To date most of the build-out of wireless networks has been to provide initial coverage to an area. Currently most major metropolitan areas and major highways have sites to provide coverage, and so the coverage build-out has moved to suburban and more rural areas. In recent months, the issues driving build-out and the demand for sites have expanded beyond basic coverage to include both "fill-in" coverage (sites for "dead spots" in the existing system) and capacity (additional sites needed in covered areas to handle the volume of callers). For these reasons, we are likely to see a "second wave" of demand for sites in populated areas that some may consider already covered, and we should continue to see a demand for new sites in all but the most remote areas.

SYSTEM TYPE ISSUES

Each of the three main types of wireless communications systems—cellular, PCS, and ESMR—has certain characteristics that affect system design. The operating frequency is one of the most important differences. Cellular and ESMR services both operate in the upper 800 MHz frequency range (or band), while PCS operates in the 1900 MHz frequency range.

Cellular and ESMR services exhibit very similar properties when operating and will be treated as one entity, called 800 MHz. Long-needle

pine trees are problematic for the 800 MHz frequency band, and the signal will partially penetrate buildings. The number of towers needed to provide acceptable system coverage will vary according to the setting. For a rural, relatively flat environment, a tower every ten to fifteen miles is usually adequate for analog systems and every three and a half to five miles for digital systems. In areas of rugged terrain or dense vegetation, the distance between sites must often be greatly reduced. In a dense urban environment, this requirement is reduced to every couple of blocks.

PCS frequencies operate at 1850 to 2000 MHz (1.85-2 GHz) and have a wavelength half that of the 800 MHz frequencies. This means a PCS signal attenuates more rapidly over distance, so more energy (power) would be required to transmit a PCS signal the same distance as for the 800 MHz frequencies. Since the operating power levels for the two systems are comparable, the PCS signal does not reach as far as signals for the 800 MHz frequency services. Consequently, PCS sites must, as a rule, be located closer to each other to provide a comparable level of system coverage. In general, the sites for PCS are placed two to three miles apart in open space. Most foliage will cause problems for PCS, and the signal does very poorly at penetrating buildings.

SITE SELECTION BASICS

The main wireless system design trade-off is tower height versus number of towers in a given area. A taller tower will allow a site to provide coverage for a larger area, and fewer towers will be required in a provider's network. As tower height decreases, the coverage area per site also shrinks. This creates the need for more sites to cover the same overall area. A simple way to describe this trade-off is: taller towers and fewer sites versus shorter towers and more sites.

RF-transparent materials can be fashioned to match elements of decorative buildings.
© OMNIPOINT COMMUNICATIONS

In general, the preferred method for locating a new wireless antenna site with minimum cost and disruption to the area is to place it on an existing tower. Many different service providers may co-locate their antennas on a single structure. However, there must be a minimum vertical distance (generally ten feet) between antennas to avoid interference problems, especially when they are operating at similar frequencies. This means that a structure can still only carry a limited number of service providers' equipment—typically three, but sometimes four or even five. And if a tower is to carry multiple antennas, it will likely need to be taller and stronger (i.e., larger) than a tower carrying only one antenna.

Unfortunately, taller and stronger towers are often at odds with other community concerns. This is important for municipalities to consider when requiring that new towers be built to allow for co-location.

The next most preferred location for a wireless antenna site is on an existing high-rise building or other structure that affords substantial height above the surrounding terrain and thereby avoids the effects of shadowing.

Finally, new sites and purpose-built structures (towers) are explored for suitability. This is when the local zoning rules are most likely to be in effect, and when the siting of wireless communication facilities can become a major issue.

WHAT WIRELESS FACILITIES LOOK LIKE

Antennas can be installed on a wide variety of existing structures as long as they provide sufficient height and structural strength. The rooftops of tall buildings are commonly used for this purpose, as are water towers, towers for high-tension power lines, and the tall light poles seen along some highways and at many ballparks.

The most commonly used types of purpose-built structures for wireless facilities are the lattice tower and

the monopole. The lattice tower is generally more stable and can generally support more weight and more carriers than a monopole. Either type may be "guyed" for greater stability, whereby cables (guy wires) connect high points on the tower or pole to anchors in the ground.

Lattice towers are typically anywhere from seventy to about 200 feet tall without guy wires, but the taller the tower, the bigger it needs to be at the base to support the weight and provide stability. Guyed lattice towers can be more than 1,000 feet tall; this type of tower is typically used for TV or radio. Lattice towers for telecommunications don't typically exceed 200-250 feet in built-up areas, but may be up to 400 feet in rural or remote areas.

Monopoles have become very popular in recent years because they are generally less visually intrusive than lattice towers and they can be cheaper and easier to build. (They can also be more expensive if the monopole is very large and built to hold many carriers.) Free-standing monopoles can be as tall as 180 feet or more, but it is important to remember that the taller the monopole, the larger and stronger the foundation it needs to support it. This support is either in the form of a concrete block buried in the ground or from a "direct-embedded" pole that is driven twenty feet or so into the ground.

> "IN GENERAL, THE PREFERRED METHOD FOR LOCATING A NEW WIRELESS ANTENNA SITE WITH MINIMUM COST AND DISRUPTION TO THE AREA IS TO PLACE IT ON AN EXISTING TOWER."

New techniques are available for camouflaging towers, so that even purpose-built antenna structures look more compatible with the local environment and are more aesthetically pleasing than the typical antenna tower structure. This "stealth" technology uses special materials and designs so that structures look like trees, signs, and even flagpoles. The flagpole designs come complete with a flag and house up to six providers. They work very well at schools, colleges, ball fields, country clubs, shopping centers, and parking lots. Another option is to place the antennas inside an existing (or purpose-built)

Facade-mounted antennas on either side of the sign are painted to match the building. • OMNIPOINT COMMUNICATIONS

structure, such as a church steeple or bell tower or those large sculptural obelisks at the entrances to some office parks, or to add an architecturally compatible "bump-up" on an existing building. In these instances, the wall or face is replaced with RF-transparent materials so the antennas are entirely hidden from view, but their operation is not impeded. You have probably driven past such antennas and never known it.

A number of companies specialize in designing and building stealth facilities, and they can be very creative. These techniques are not typically employed, however, unless a community requires it, because they are more expensive than a basic lattice or monopole. It is also important to consider that these stealth type installations are sometimes at a lower elevation (height) than a tower would be and in such a case would cover less area. In this situation it might then be necessary to have additional sites in the network to provide the same level of overall system coverage.

There are a variety of antenna types used in wireless systems: stick, whip, and panel antennas are some of the most common. The location of the antenna, the type of structure, and the desired coverage area generally determine which type of antenna is used.

This lattice tower in Natick sports whip, panel, and dish antenna systems. © LEONIE FOY

The associated equipment needed for a site can be located in its own building or enclosure near the structure, or—if on a building—on the roof or elsewhere in that building. This equipment may also be located underground if aesthetics are an issue. In either case, the service provider is going to need to have ready access both to the antennas and the associated equipment, and the provider is going to need to secure them from the general public. This is why most tower sites have an access road or driveway and a perimeter fence. ■

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Health and Safety Issues of Exposure to Radio-Frequency Emissions

BY PETER VALBERG

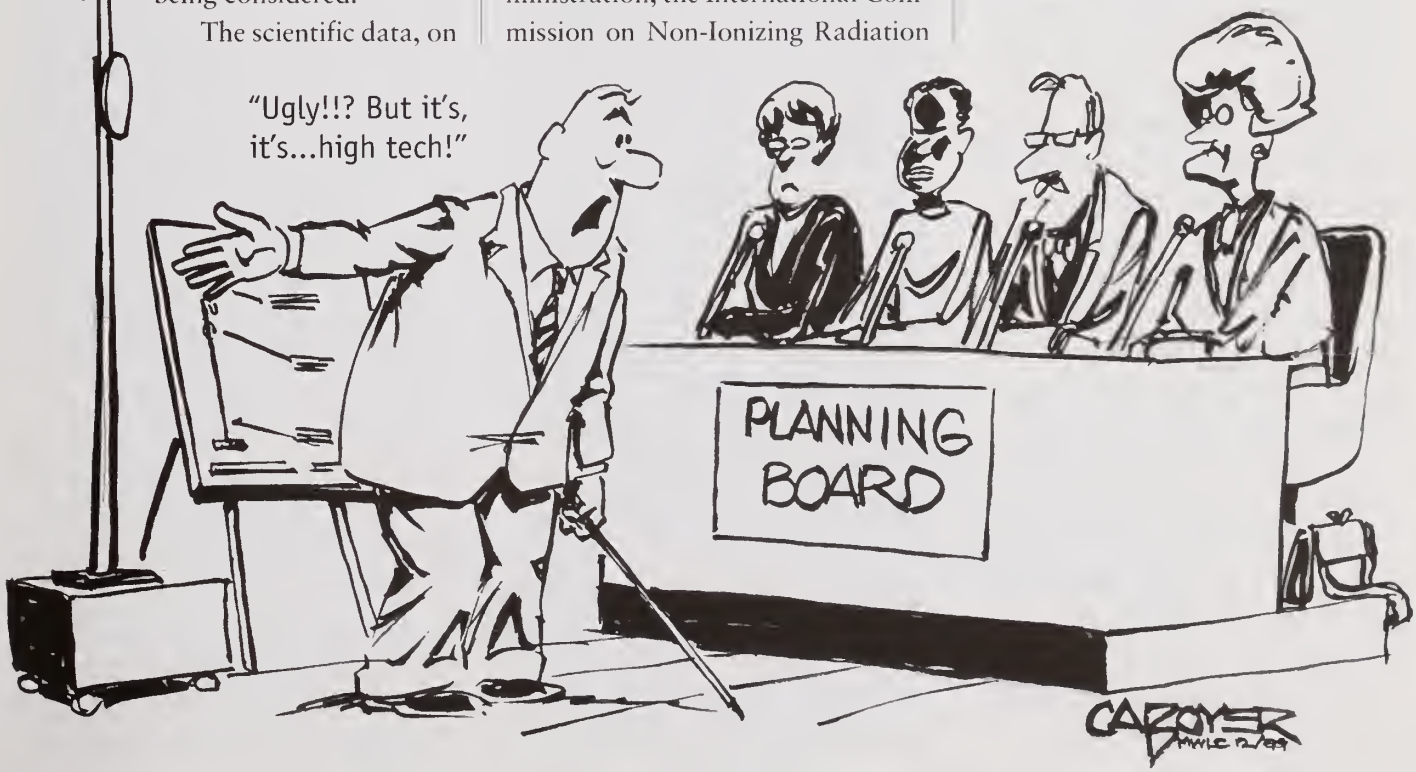
The Telecommunications Act of 1996 devotes many pages to discussion of scientific literature regarding wireless telephone technology, as well as the potential for health risks and associated safety standards. The text of the law summarizes guidelines from several different regulatory agencies, all of which support the safety of wireless telephone technology. This technical material, presented in the law, was intended to forestall repetitive debate on the scientific evidence each time an antenna installation is being considered.

The scientific data, on which the safety standards in the 1996 Telecommunications Act are based, represent the accumulated knowledge of many years of laboratory work and many years of human experience with radio frequency (RF) waves (radio, television, navigation, telemetry, mobile phones, radar). Research findings on RF waves and health have been assembled and reviewed by many independent consensus groups of research, medical and public health scientists.

These groups include the World Health Organization, the National Radiation Protection Board (U.K.), the U.S. Environmental Protection Agency, the U.S. Food and Drug Administration, the International Commission on Non-Ionizing Radiation Protection, Health Canada, and the National Council on Radiation Protection and Measurements (U.S.). The reports of these groups, written by medical doctors, biologists, engineers, and toxicologists, are voluminous, thorough and even-handed. With minor differences, these panels concur that the current guidelines for the operation of wireless telephones and wireless telephone base antennas protect the safety of nearby residents and the public.

THE NATURE OF SCIENTIFIC EVIDENCE

Understanding the potential toxicity in humans of any particular exposure



is an integrative process that strives for coherence among several lines of evidence. At the most fundamental level, scientists believe that the operation of living organisms, although only partially understood, is bounded by the accepted principles of physics, chemistry, and biology.

First, scientists ask whether specific levels of RF exposure, on a physical, chemical, and biological basis, have the potential to adversely affect the operation of life processes.

Second, laboratory scientists test the outcome of RF exposure on animals and on cells isolated from the body. Such tests are susceptible to error, particularly for weak RF exposures and subtle responses—meaning that the outcome differences between the exposed and control systems may not be due to the exposure in question. Consequently, experiments on RF exposures need to be examined for validity with regard to a number of criteria (e.g., physics of electric and magnetic fields, accurate measurement of the radio wave exposure, cell biology/molecular biology methodology, animal toxicology/physiology/pathology, and statistical analysis).

Third, researchers examine data from human studies (volunteers, clinical studies and epidemiology). Although human studies are potentially of the greatest relevance—not requiring extrapolation from in vitro systems or from non-human species—the uncontrolled nature of human lifestyle and experience makes it difficult to control bias, confounding, and exposure misclassification. Epidemiology alone can seldom identify a causal association unless the results are strong, specific, and coherent.

There are volumes of scientific and medical literature on investigations looking for possible health effects from RF waves. An adequate picture cannot be gained from only selected studies (even less so from anecdotal stories about RF "effects"). Just because a published, peer-reviewed study can be identified does not mean that the scientific community accepts the results of that study as valid. Scientists having the qualifications and training to interpret the strengths and weaknesses of what was actually done must weigh the scientific credibility and interpretation of each study. This sort of thorough review is what formed the basis of the conclusions of the blue-ribbon panels of scientific experts.

"ELECTROMAGNETIC WAVES, ALSO CALLED 'RADIO WAVES' OR 'RADIO FREQUENCY RADIATION,' ARE GENERATED BY MOVING ELECTRIC CHARGES. A GOOD ANALOGY IS THE WAVE PATTERN PRODUCED IN A LAKE IF YOU PERIODICALLY POKE A STICK INTO THE SURFACE."

THE NATURE OF RF WAVES

Electromagnetic waves, also called "radio waves" or "radio frequency radiation," are generated by moving electric charges. A good analogy is the wave pattern produced in a lake if you periodically poke a stick into the surface. As you do this, waves are created on the surface of the lake, and the waves propagate outward from the point of disturbance. The stick pushing up and down is analogous to the electric charges in an antenna moving up and down, and the waves produced are analogous to the electromagnetic waves propagating away from the antenna.

The electric field can be visualized as lines coming out from the charge radially, like the spokes on a wheel (except that the electric field lines continue outward indefinitely). When you move the charge, these lines follow it so that they are always coming out radially from the charged particle. If you shake the charged particle fast enough, the lines cannot instantaneously reorient toward the new position of the particle, and you get "kinks" in the electric field lines that move outward at the speed of light. That is, electromagnetic waves are essentially kinks in the electric field lines that occur at a frequency corresponding to the frequency at which you are shaking the charge. Magnetic fields are also produced because moving charges produce magnetic fields, so the total phenomenon is called "an electromagnetic wave."

The electromagnetic spectrum is composed of regions characterized by frequency, which is expressed in "hertz" (Hz), equivalent to "cycles per second." The frequency bands extend from extremely low frequencies (tens of hertz) up through radio waves (millions of hertz, or megahertz [MHz]), infrared radiation (mil-

lions of megahertz), visible light (billions of megahertz), X rays (trillions of megahertz), and gamma rays (quadrillions of megahertz). Electromagnetic waves from different parts of the spectrum affect matter in different ways.

The spectrum is divided into two fundamental categories: ionizing and non-ionizing. The ionizing part of the spectrum begins with ultraviolet and extends to higher frequencies into X rays and gamma rays. Ionizing radiation can break apart biological molecules, such as DNA. Thus, ionizing radiation can produce irreversible damage that accumulates over time. Non-ionizing radiation, such as radio waves, belongs to the portion of the electromagnetic spectrum in which the photons, at lower frequencies, lack the energy to alter the chemical bonds that hold molecules together.

Radio-wave frequencies, in the non-ionizing part of the spectrum, cover the range from about 300,000 hertz to 3 billion hertz (that is, 300 kilohertz [KHz] to 3 gigahertz [GHz]). Wireless communications rely on a carrier frequency that is different for each communication signal, but for wireless phones it is typically somewhere in the range of 800 megahertz to 2 gigahertz. For example, in the case of digital cellular telephone services (PCS), the carrier frequency is about 1,960 megahertz, which is within the ultra-high frequency (UHF) region of the electromagnetic spectrum (300 to 3,000 MHz).

By itself, an RF carrier wave, an unchanging continuous electromagnetic wave, carries no information and cannot communicate anything. Information is imposed on the carrier wave by a modulation process that alters it by changing its amplitude, frequency, or phase in step with the voice frequency being imposed. Alternatively, the voice signal can be coded into computer bits, and the carrier wave can be modulated by changing its amplitude or frequency in discrete steps (digital modulation).

Scientists have asked whether biological interactions depend on the type of information being transmitted (e.g., voice or music or computer bits). The physical energy of the RF waves depends primarily on the power of the carrier wave, and it does not seem that the biological impact (or non-impact) depends on the information content.

A monopole with co-location of three carriers. © BELL ATLANTIC MOBILE

SOURCES AND POWER LEVELS OF RF SIGNALS

Wireless telephone technology is responsible for only a tiny portion of the electromagnetic energy in our environment. Visible light is by far the major source of energy when considering the whole electromagnetic spectrum. And even in the RF portion of the spectrum, the following list of sources includes many that produce much more RF energy than wireless communications technology.

- Commercial radio (AM and FM)
- Commercial television (VHF, UHF, and digital)
- Marine and aviation radio services, aviation radar, police radar
- Public emergency, fire and police dispatch services
- Amateur (ham) radio operators, international short-wave broadcasts
- Pagers, cellular and PCS telephones
- Cordless telephones, baby monitors, wireless toys, walkie-talkies
- Computer monitors, televisions, CD players, computer games
- Microwave oven leakage
- Microwave links for computers, television, and telephone
- Satellite television/communications, global positioning systems (GPS)
- Medical procedures, such as diathermy and magnetic resonance imaging

This list shows that radio frequency exposure is nothing new in our environment.

The total amount of RF energy released by wireless telephone handsets is less than one watt. Wireless telephone base antennas, even at maximum capacity, have power levels of 100 to 1,000 watts, far below those of typical radio and television broadcast stations, which are licensed to operate at power outputs of 10,000 to 1 million watts. All antennas, however, must comply with FCC standards, so that even in close proximity to the base of any antenna tower, RF energy levels fall below regulatory and health standards (which, depending on frequency, range from 0.2 to 20 mW per square centimeter).

The energy emitted from any antenna is dissipated in all directions, so the RF energy level drops off rapidly with increasing distance. For wireless telephone base antennas, not only are the "maximum impacts" very small, but the levels fall even lower as you move away from the point at which RF energy is greatest.

The human body, by virtue of being alive and warm, generates heat energy (electromagnetic energy in the infrared portion of the spectrum) at a rate of about 100 watts, even when we sleep. The radiated electromagnetic energy from our bodies can be seen by an "infrared" camera, even in complete darkness. When working and exercising, our body's energy output increases from two- to tenfold (up to 200 to 1,000 watts). Moreover, the amount of energy our bodies can absorb in the form of radio waves in the ambient environment is considerably below what our body absorbs from other sources.

When we lay on the beach at high noon, our skin continuously absorbs about 200 watts of energy from sunlight. Or, put another way, at the earth's surface, electromagnetic energy from the sun bathes us with about 0.15 watts of light energy per square centimeter of skin. That is, the sun's energy level at the surface of the earth is about 150 mW/cm^2. For RF electromagnetic energy at the frequency of PCS wireless installations (about 1,960 MHz), the standard for areas accessible to the public (residences, schools, hospitals, parks) is 1 mW/cm^2 *(see table.)* The maximum power levels from wireless telephone RF are much below the levels allowable by the RF safety standard and much below other sources of electromagnetic energy in our environment.

Table 1. A Comparison of Electromagnetic Energy Exposures

Electromagnetic energy in sunlight at the earth's surface *(noon, summer day)*	Applicable standard for 1,930 MHz RF wave energy *(public and residential areas)*	Typical RF levels from wireless telephone base station antennas *(at any public location)*
150 mW/cm^2	1 mW/cm^2	less than ~0.005 mW/cm^2

BASIS OF RADIO WAVE SAFETY STANDARDS

In the UHF range, where we find wireless communications, the quantity used most often to express "dose" of RF is the rate of energy deposition per unit mass of body tissue, or the specific absorption rate (SAR). The SAR is generally given in watts per kilogram (W/kg).

The basis of radio wave exposure limits rests primarily on the observation that behavioral changes occur in animals when the heat load imposed by incident RF becomes perceptible (at about 4 W/kg). The occupational limit is set at one-tenth of this level, or 0.4 W/kg. The limit for permissible exposure for the general public is set at one-fifth of the occupational value, or 0.08 W/kg. These levels represent an extremely small amount of heat delivery. For example, heat delivery at 0.4 W/kg will melt an ice cube in ten days (at 0 degrees Centigrade, assuming no other sources of heat input).

RF standards are developed from SAR levels. The greatest whole-body absorption of RF energy occurs in the frequency band from about 30 to 300 megahertz (i.e., below the frequencies of wireless telephone technology). Above this frequency, the percentage of absorbed power decreases, although localized energy absorption may occur. A useful benchmark is that at 1,000 megahertz, the maximum permissible exposure level for the general public is about 0.67 mW/cm^2.

SUMMARY

It is appropriate that we be vigilant about reviewing potential health effects of new technologies, and that numerous regulatory and health agencies periodically examine the safety of RF wave transmissions. Re-

cent news, however, on potential health effects of wireless phones has tended toward alarmism stating that there may be some direct evidence of possible harm from their use. New research continues to add to the vast quantity of literature available, and the conclusions of this research are being monitored. So far, however, no valid basis has been established for questioning the safety of the current, health-protective exposure limits, as presented in the 1996 Telecommunications Act.

> “REGULATORY AND PUBLIC HEALTH CONSENSUS GROUPS ARE UNANIMOUS IN REJECTING THE CONTENTION THAT WIRELESS TELEPHONE BASE ANTENNAS OPERATED ACCORDING TO FCC STANDARDS ARE CONTRIBUTING TO INCREASES IN ANY DISEASE STATISTIC.”

The rapid growth of wireless phone use has focused attention on the potential for adverse health effects from this technology, but, in the general urban environment, wireless phone RF fields are considerably weaker than other types of RF fields, from sources such as aviation radar, AM and FM radio, and television antennas. Although some reports in the scientific literature have been used to fuel anxiety about health concerns, careful reviews of the literature for validity, coherence, reproducibility, and relevance have not identified legitimate reasons to rethink the FCC standards. Regulatory and public health consensus groups are unanimous in rejecting the contention that wireless telephone base antennas operated according to FCC standards are contributing to increases in any disease statistic. ■

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A whip antenna peeks above the top edge of this water storage tank. Note the compact size of the associated equipment shelter on the ground.
OMNIPOINT COMMUNICATIONS

Dictionary of Wireless Terms and Abbreviations

EDITED BY THE
CELLULAR TELECOMMUNICATIONS INDUSTRY ASSOCIATION

"A" Carrier See Non-wireline Cellular Company.

"A-Block" Carrier A 30 MHz PCS provider serving a Major Trading Area in the frequency block 1850–1865 MHz paired with 1930–1945 MHz.

A/B Switch A feature found on newer cellular telephones permitting the user to select either the "A" (*non-wireline*) carrier or the "B" (wireline) carrier when roaming away from home.

Access Fee A special fee that local telephone companies are allowed to charge all telephone customers for the right to connect with the local phone network.

Advanced Intelligent Networks Systems that allow a wireless user to make and receive phone calls while roaming in areas outside the user's "home" network. These networks, which rely on computers and sophisticated switching techniques, also provide many Personal Communications Services features such as "one person/one phone."

Air Time Actual time spent talking on the wireless telephone. Most carriers bill customers based on how many minutes of air time they use each month. The more minutes of time spent talking on the phone, the higher the bill.

Alphanumeric A message or other type of readout containing both letters ("alphas") and numbers ("numerics"). Regarding wireless, "alphanumeric memory dial" is a special type of dial-from-memory option that displays both the name of the individual and that individual's phone number on the wireless phone handset. The name also can be recalled by using the letters on the phone keypad. By contrast, standard memory dial recalls numbers from number-only locations.

AMPS, Advanced Mobile Phone Service The term used by AT&T's Bell Laboratories (prior to the break-up of the Bell System in 1984) to refer to its cellular technology. The AMPS standard has been the foundation for the industry in the United States, although it has been slightly modified in recent years. "AMPS-compatible" means equipment designed to work with most cellular telephones.

Analog The traditional method of modulating radio signals so that they can carry information. AM (amplitude modulation) and FM (frequency modulation) are the two most common methods of analog modulation.

ANSI The American National Standards Institute, a non-profit, privately funded membership organization that coordinates the development of U.S. voluntary national standards and is the U.S. representative to non-treaty international standards-setting entities including the International Organization for Standardization (ISO) and the International Electrotechnical Commission.

Antenna A device for transmitting and/or receiving signals. The size and shape of antennas are determined, in large part, by the frequency of the signal they are receiving. Antennas are needed on both the wireless handset and the base station.

Authentication A process used by the wireless carriers to verify the identity of a mobile station.

"B" Carrier See Wireline Cellular Carrier.

"B-Block" Carrier A 30 MHz PCS carrier serving a Major Trading Area in the frequency block 1870–1885 MHz paired with 1950–1965 MHz.

Bandwidth A relative range of frequencies that can carry a signal without distortion on a transmission medium.

Base Station The central radio transmitter/receiver that maintains communications with mobile radio telephones within a given range (typically a cell site). See also Cell, Cell Site.

BTA, Basic Trading Area A service area designed by Rand McNally and adopted by the FCC to promote the rapid deployment and ubiquitous coverage of Personal Communications Services (PCS). Built from county boundaries, BTAs generally cover a city and its surrounding environs. BTAs are component parts of Major Trading Areas (MTAs). There are 493 BTAs in the United States. See also MTA.

"C-Block" Carrier A 30 MHz PCS carrier serving a Basic Trading Area in the frequency block 1895–1910 MHz paired with 1975–1990 MHz.

CDMA, Code Division Multiple Access A spread-spectrum approach to digital transmission. With CDMA, each conversation is digitized and then tagged with a code. The mobile phone is then instructed to decipher only a particular code to pluck

the right conversation off the air. The process can be compared in some ways to an English-speaking person picking out in a crowded room of French speakers the only other person who is speaking English. See also **Digital Modulation.**

CDPD, Cellular Digital Packet Data Technology that allows data files to be broken into a number of "packets" and sent along idle channels of existing cellular voice networks.

Cell The basic geographic unit of a wireless system. Also, the basis for the generic industry term "cellular." A city or county is divided into smaller "cells," each of which is equipped with a low-powered radio transmitter/receiver. The cells can vary in size depending upon terrain, capacity demands, etc. By controlling the transmission power, the radio frequencies assigned to one cell can be limited to the boundaries of that cell. When a wireless phone moves from one cell toward another, a computer at the Mobile Telephone Switching Office (MTSO) monitors the movement and at the proper time, transfers (or "hands off") the phone call to the new cell and another radio frequency. The hand-off is performed so quickly that it's unnoticeable to the callers. See also **Base Station, Cell Site.**

Cell Site The location at which communications equipment is located for each cell. A cell site includes antennas, a support structure for those antennas, and communications equipment to connect the site to the rest of the wireless system. This equipment is normally housed in a small shelter at the based of the site. Although many antennas are placed on towers, where existing structures provide for sites that are higher than their surroundings, antennas will be placed on them. For example, antennas have been placed on water towers, grain silos, and building rooftops. See also **Base Station, Cell.**

Cell Splitting A means of increasing the capacity of a wireless system by subdividing or splitting cells into two or more smaller cells.

CGSA, Cellular Geographic Service Area The actual area in which a cellular company provides cellular service. This area may be somewhat smaller than the MSA or RSA surrounding it. See also **MSA, RSA.**

Channel A path along which a communications signal is transmitted.

Co-location The siting of two or more separate companies' wireless antennas on the same support structure. See also **Cell Site.**

CMRS, Commercial Mobile Radio Service The regulatory classification that the FCC uses to govern all commercial wireless service providers, including Personal Communications Services, cellular, and Enhanced Specialized Mobile Radio.

"D-Block" Carrier A 10 MHz PCS carrier serving a Basic Trading Area in the frequency block 1865-1870 MHz paired with 1945-1950 MHz.

Digital Modulation A method of encoding information for transmission. Information (in most cases a voice conversation) is turned into a series of digital bits—the 0s and 1s of computer binary language. At the receiving end, the information is reconverted to its original form. Digital transmission offers a cleaner signal and is virtually immune to the problems of analog modulation such as fading and static. (To appreciate the difference, compare the fidelity of a standard LP record with that of a digital compact disk.) Digital transmission has been embraced by the wireless industry because it offers major gains in capacity compared to analog. See also **CDMA, TDMA,** and **GSM.**

Wireless communications facility equipment shelter/base station and security fence. © BELL ATLANTIC MOBILE

"E-Block" Carrier A 10 MHz PCS carrier serving a Basic Trading Area in the frequency block 1885–1890 MHz paired with 1965–1970 MHz.

EMC, Electromagnetic Compatibility The ability of equipment or systems to be used in their intended environment within designed efficiency levels without causing or receiving degradation due to unintentional electromagnetic interference. Proper shielding of devices reduces interference.

EMI, Electromagnetic Interference Interference in signal transmission or reception caused by the radiation of electrical and magnetic fields. See also EMC.

ESMR, Enhanced Specialized Mobile Radio Digital mobile telephone services offered to the public over channels previously used for two-way analog dispatch services. See also SMR.

ESN, Electronic Serial Number The unique number assigned to a wireless phone by the manufacturer. According to the Federal Communications Commission, the ESN is to be fixed and unchangeable—a sort of unique fingerprint for each phone. See also MIN.

ETACS, Extended Total Access Communications Systems The conventional wireless technology used in the United Kingdom and other countries. It was developed from the U.S. AMPS technology.

"F-Block" Carrier A 10 MHz PCS carrier serving a Basic Trading Area in the frequency block 1890–1895 MHz paired with 1970–1975 MHz.

FCC, Federal Communications Commission The government agency responsible for regulating telecommunications in the United States.

FDMA, Frequency Division Multiple Access Method of radio transmission that allows multiple users to access a group of radio frequency bands without interference.

Frequency A measure of the energy, as one or more waves per second, in an electrical or light-wave information signal. A signal's frequency is stated in either cycles-per-second or Hertz (Hz). See also Hertz.

Frequency Re-use The ability to use the same frequencies repeatedly within a single system, made possible by the basic design approach for wireless. Since each cell is designed to use radio frequencies only within its boundaries, the same frequencies can be re-used in other cells not far away with little potential for interference. The concept is akin to an FM radio station in Chicago using the same frequency as one in Denver without interference. The re-use of frequencies is what allows a wireless system to handle a huge number of calls with a limited number of channels.

GHz, GigaHertz Billions of Hertz. Personal Communications Services operate in the 1.9 GHz band of the electromagnetic spectrum. See also Hertz, KHz, MHz.

GSM, Groupe Speciale Mobile or Global Standard for Mobile A time-division based standard for digital wireless transmissions. It is most prevalently used in Europe. See also Digital Modulation, TDMA.

Guyed A type of wireless transmission tower that is supported by thin guy wires. See also Monopole.

Hand-off The process by which the Mobile Telephone Switching Office (MTSO) passes a wireless phone conversation from one radio frequency in one cell to another radio frequency in another cell. It is performed quickly enough that callers don't notice. See also MAHO.

Hands-free A feature that permits a driver to use a wireless car phone without lifting or holding the handset. An important safety feature.

Hertz A measurement of electromagnetic energy, equivalent to one "wave" or cycle-per-second. See also KHz, MHz, GHz.

IMSI, International Mobile Station Identifier A number assigned to a mobile station by the wireless carrier identifying the mobile station nationally and internationally. See also MIN, TMSI.

Interconnection The routing of telecommunications traffic between the networks of different communications companies.

IXC, Interexchange Carrier A long-distance phone company.

KHz, KiloHertz Thousands of Hertz. Each wireless phone call occupies only a few KiloHertz. See also Hertz, MHz, GHz.

LEC, Local Exchange Company The traditional, local, wired phone company.

MAHO, Mobile Assisted Hand-off A process in which the wireless mobile station assists the base station in assigning a voice channel by reporting its surrounding RF signal strengths to the base station. See also Hand-off .

Message Alert A light or other indicator on a wireless phone that notifies a user that a call has come in. A useful feature especially if the wireless subscriber has voice mail. Also called a "call-in-absence" indicator.

MHz, MegaHertz Millions of Hertz. Cellular and ESMR systems operate in the 800 and 900 MHz bands of the electromagnetic spectrum. See also Hertz, KHz, GHz.

MIN, Mobile Identification Number A number assigned by the wireless carrier to a customer's phone. The MIN is meant to be changeable, since the phone could change hands or a customer could move to another city. See also **ESN, IMSI, TMSI.**

Mobile Satellite Service Communications transmission service provided by satellites. A single satellite can provide coverage to the entire United States.

Mobile (or Car) Phone A type of wireless phone that is installed in a car and used with an antenna on the outside of the car. The equipment is powered by the car's battery, and in models that are installed in the trunk, only the handset is mounted near the driver. Operating at powers up to three watts, a mobile phone often provides a stronger signal than a portable. See also **Portable, Transportable.**

Monopole A slender self-supporting tower on which wireless antennas can be placed. See also **Guyed.**

MSA, Metropolitan Statistical Area An MSA denotes one of the 306 largest urban population markets as designated by the U.S. government. Two cellular operators are licensed in each MSA. See also **CGSA, RSA.**

MSC, Mobile Switching Center See **MTSO.**

MTA, Major Trading Area A service area designed by Rand McNally and adopted by the FCC to promote the rapid deployment and ubiquitous coverage of Personal Communications Services (PCS). Built from Basic Trading Areas (BTAs), MTAs are centered on a major city and generally cover an area the size of a state. There are 51 MTAs in the United States. See also **BTA.**

MTSO, Mobile Telephone Switching Office The central computer that connects a wireless phone call to the public telephone network. The MTSO controls the entire system's operations, including call monitoring, billing, and hand-offs.

NAM, Number Assignment Module The NAM is the electronic memory in the wireless phone that stores the telephone number and electronic serial number.

NEPA, The National Environmental Policy Act of 1969 An Act of Congress that requires federal agencies to take into consideration the potential environmental effects of a particular proposal such as construction of a radio station.

No-answer Transfer A service provided by wireless carriers that automatically transfers an incoming wireless call to another phone number if the wireless subscriber is unable to answer. Most no-answer transfer systems will automatically transfer the call on the first ring if the wireless phone is turned off, but will not make the transfer until the third or fourth ring if the phone is on.

Nondirectional Antenna An antenna that transmits and receives equally well in all directions, usually on one plane; also called an omnidirectional antenna.

Nonionizing Emissions Radio waves, infrared rays, and visible light rays, none of which affect an atom's electrical balance.

Non-wireline Cellular Carrier The Block "A" carrier. The "A" originally stood for "alternate" system, i.e., the non-Bell or "B" carrier in a market. The FCC, in setting up the licensing and regulatory rules for cellular, decided to license two cellular systems in each market. It reserved one for the local telephone company and opened a second system—the Block A system—to other interested applicants. The distinction between Block A and Block B was meaningful only during the licensing phase at the FCC. Once a system is constructed, it can be sold to anyone. Thus in some markets today, both the A and B systems are owned by telephone companies—one happens to be the local phone company for the area and the other is a phone company that decided to buy a cellular system outside its home territory. See also **Wireline Cellular Carrier.**

Off-peak The periods of time (usually after the business day or on weekends) during which carriers offer discounted air time charges.

PCS, Personal Communications Services FCC terminology describing two-way, personal, digital wireless communications systems

Peak The period of time (usually the business day) during which wireless customers can expect to pay full service rates.

Personal Digital Assistants Portable computing devices capable of transmitting data. These devices make possible services such as paging, data messaging, electronic mail, stock quotations, handwriting recognition, personal computing, facsimile, date book, and other information-handling capabilities.

Picocell A wireless base station with extremely low output power designed to cover an extremely small area, such as one floor of an office building.

POP Short for population. One "POP" equals one person. For example, a carrier whose market serves one million people is said to offer service to one million POPs. In the wireless industry, systems are valued financially based on the population of the market served.

Portable Portable phones are small, hand-held units that can fit in a pocket, briefcase, or purse. Using an attachment, many can be plugged into an automobile cigarette lighter to save battery power. As a smaller, lighter phone, a portable operates at power levels of up to 6/10ths of a watt. Digital phones are almost always portable phones. See also **Mobile, Transportable.**

RF, Radio Frequency A frequency well above the range of human hearing.

Roaming The ability to use a wireless phone to make and receive calls in places outside one's home calling area.

RSA, Rural Service Area One of the 428 FCC-designated rural markets across the United States. There are two cellular carriers licensed in each RSA. See also **MSA, CGSA.**

Satellite/Wireless Phone A dual-mode wireless phone that uses Mobile Satellite Service when it is out of range of the wireless network coverage.

Service Charge The amount paid each month to receive wireless service. This amount is fixed and is to be paid regardless of how much or how little the wireless phone is used.

Shielding The use of a particular material to shield an electronic component or circuit from the effects of external electric or magnetic fields.

SMR, Specialized Mobile Radio Private business service using mobile radiotelephones and base stations similar to other wireless services. It is usually used in dispatch applications, such as delivery companies or taxicab organizations. Specialized Mobile Radio is the forerunner of ESMR service. See also **ESMR.**

Standby Time The amount of time a fully charged wireless portable or transportable phone can be on before the phone's battery will lose power. See also **Talk Time.**

Talk Time The length of time one can talk on a portable or transportable wireless phone without recharging the battery. The battery capacity of a phone is usually expressed in terms of "minutes of talk time" or "hours of standby time." When one is talking, the phone draws more power from the battery. See also **Standby Time.**

TDMA, Time Division Multiple Access A method of digital wireless communications transmission allowing a large number of users to access (in sequence) a single radio-frequency channel without interference by allocating unique time slots to each user within each channel. See also **Digital Modulation.**

Telecommunications Act of 1996 Signed into law by President Clinton on February 8, 1996, it establishes a pro-competitive, deregulatory framework for telecommunications in the United States.

TMSI, Temporary Mobile Station Identifier A mobile station identifier (MSID) sent over the air interface and assigned dynamically by the network to the mobile station. See also **MIN, IMSI.**

Transportable Phone Transportable phones, or "bag phones" are essentially car phones with the handset, antenna, and battery packaged together in a carrying case. They can be plugged into a car's cigarette lighter or can operate off of a portable battery pack for use anywhere. Like a mobile phone, transportable phones can operate at up to three watts of power. Although technically "portable," the transportable phone should not be confused with the handheld, one-piece wireless phone. See also **Portable, Mobile.**

Vocoder A device used to convert speech into digital signals. See also **Digital Modulation.**

Voice Mail A computerized answering service that answers a call, plays a greeting, and records a message. Depending on the sophistication of the service, it also can notify the subscriber, via pager, that he or she has received a call. Also called voice messaging.

Voice-activated Dialing A feature that permits one to dial a phone number by speaking to a wireless phone instead of using a keypad. The feature contributes to convenience as well as driving safety.

Wireless Describing radio-based systems that allow transmission of telephone and/or data signals through the air without a physical connection, such as a metal wire or fiber optic cable.

Wireline Cellular Carrier The Block "B" carrier. Under the FCC's initial cellular licensing procedures, the Block B carrier is the local telephone company's licensee. The FCC reserved one of the two systems in every cellular market for the local telephone (or "wireline") company. With initial licensing complete, the distinction has slowly disappeared. The local phone company can sell its cellular system to anyone. See also **Non-Wireline Cellular Carrier.**

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Many different structures can accommodate wireless telecommunications facilities. Nextel Communications rebuilt this existing sign, utilizing radio-frequency transparent material, in order to house its antennas inside. © NEXTEL COMMUNICATIONS

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